THE JOURNAL OF GAS LIGHTING
WATER SUPPLY & SANITARY IMPROVEMENT

VOL. CX. No. 2458.] LONDON, JUNE 21, 1910. [62ND YEAR. PRICE 6d.

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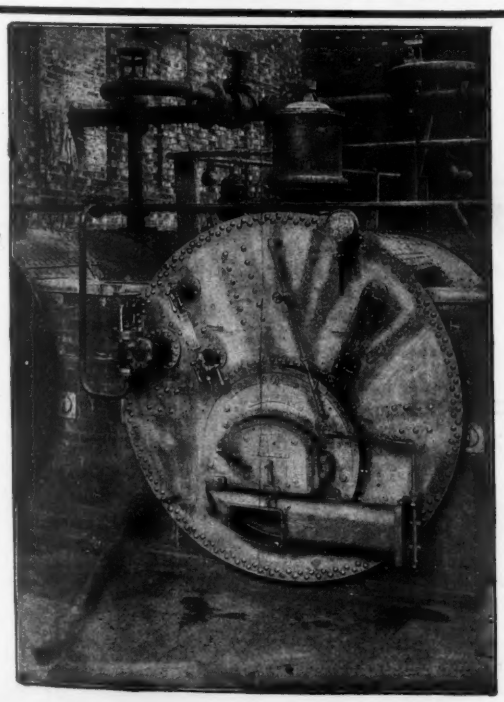

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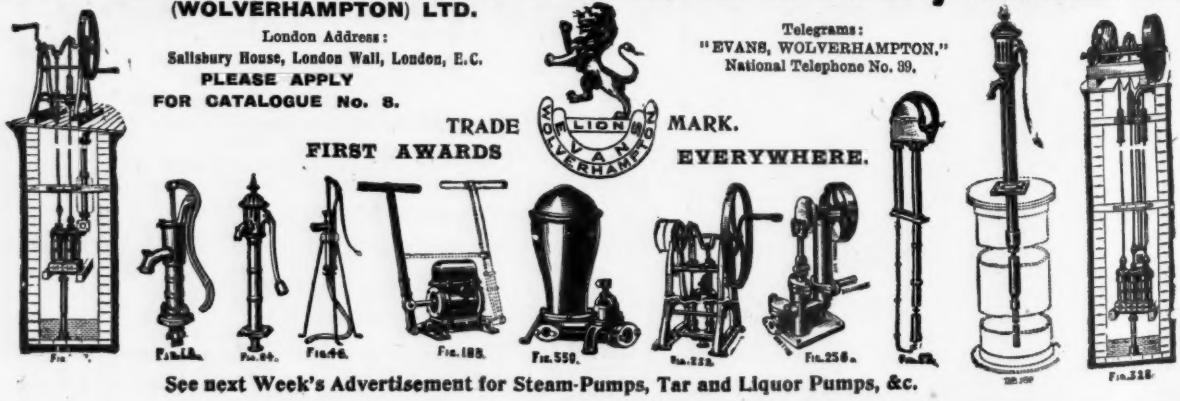

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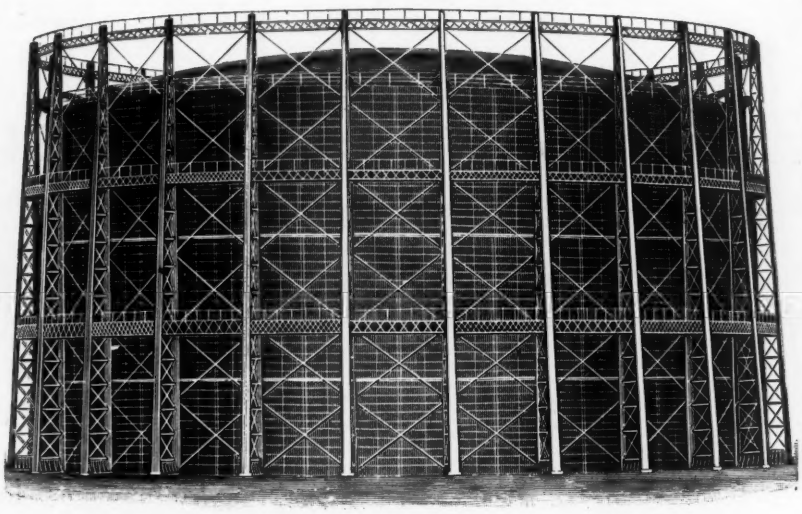

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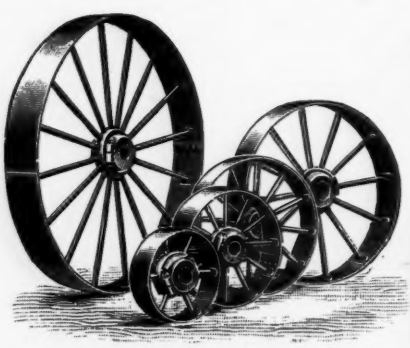

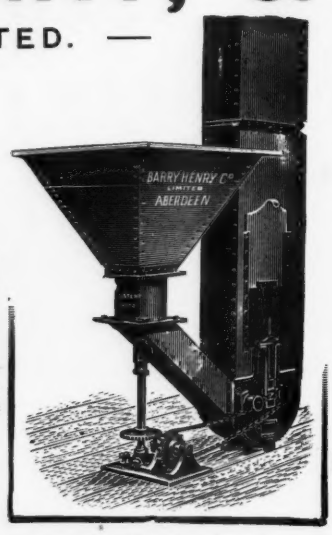

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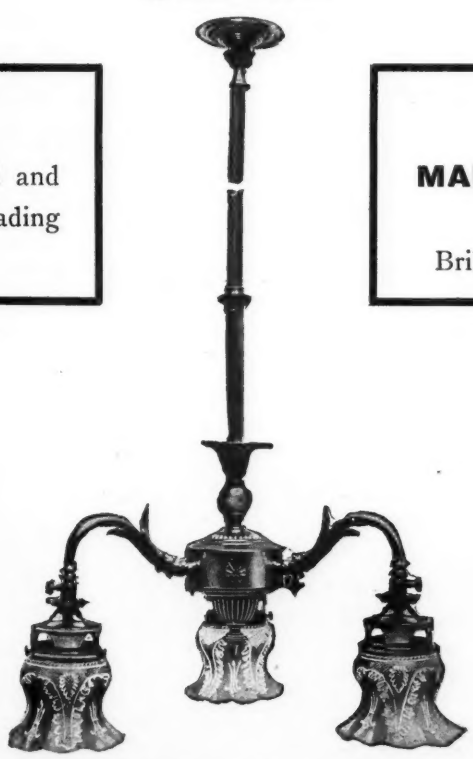

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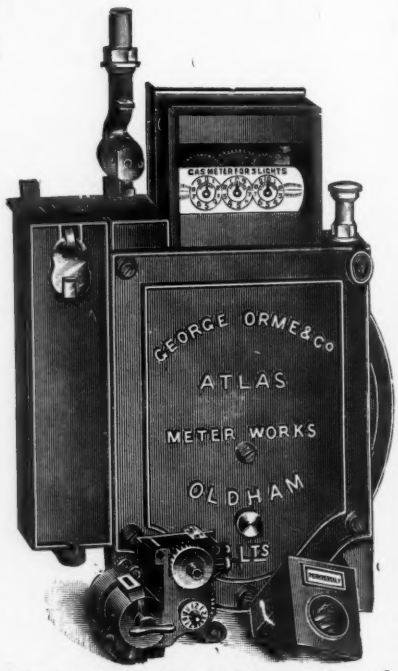

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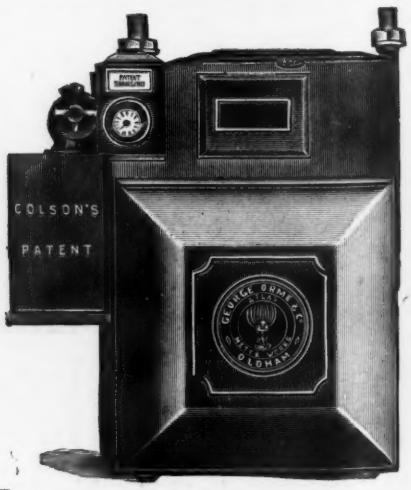

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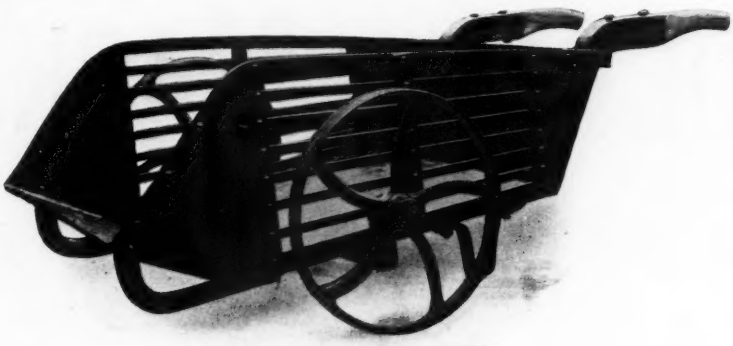

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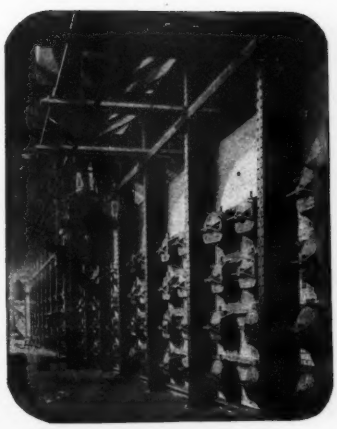

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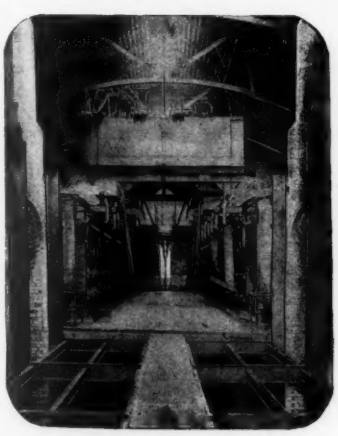

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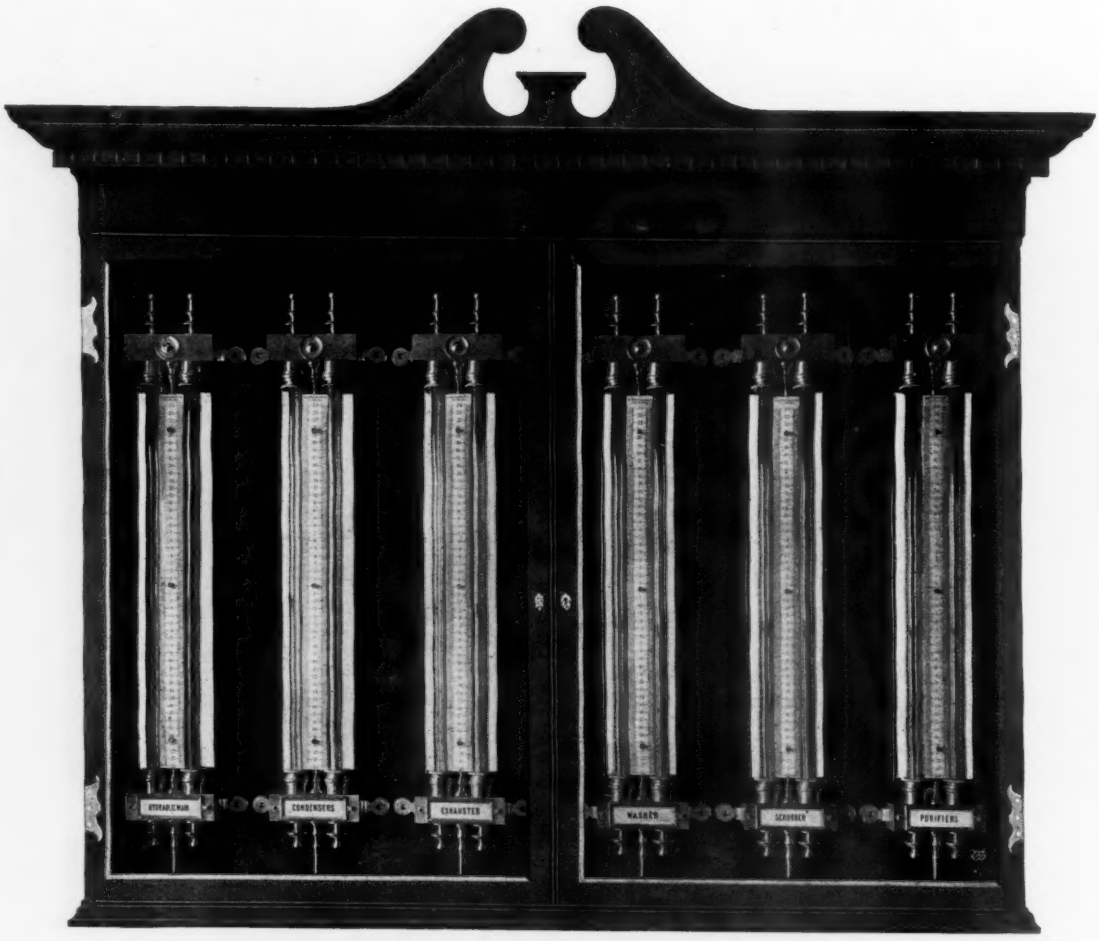

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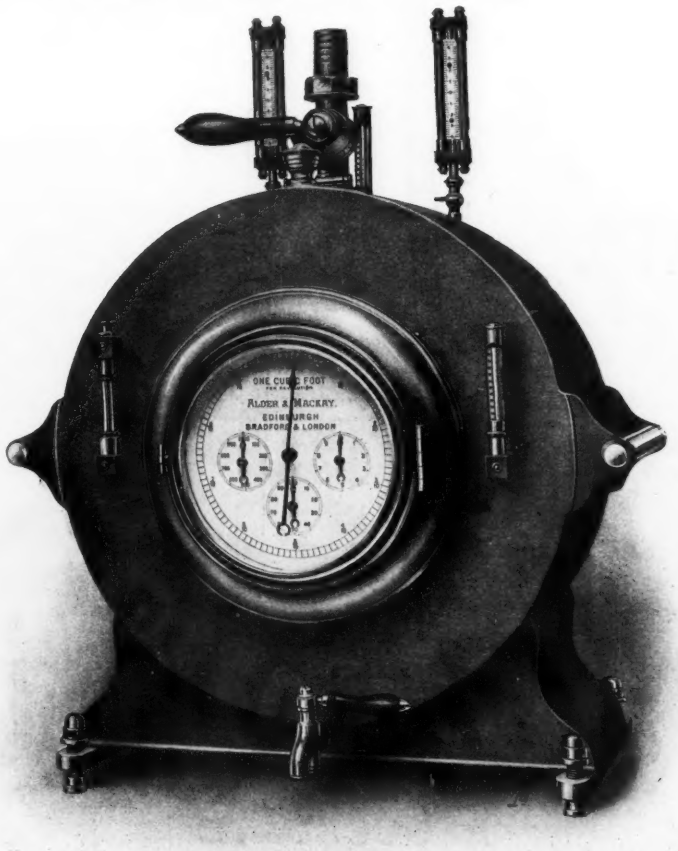

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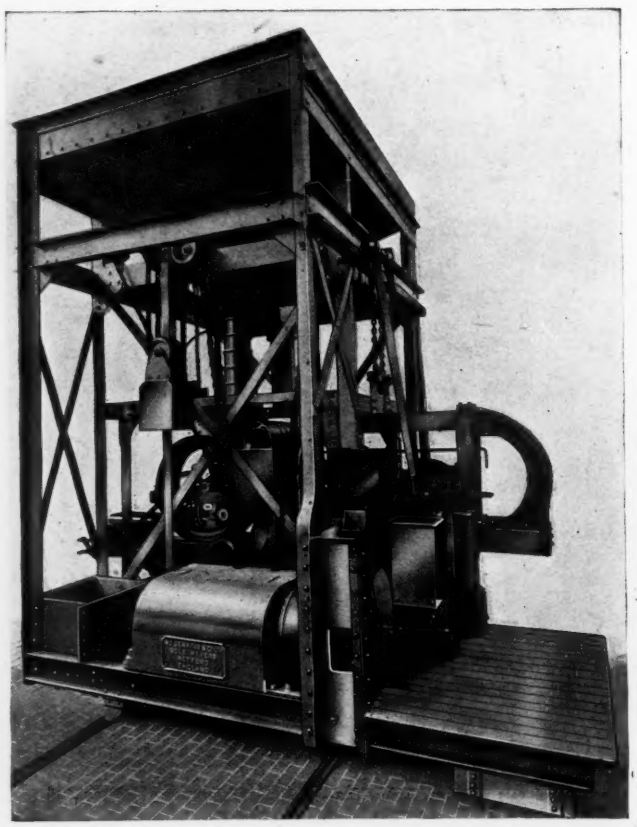

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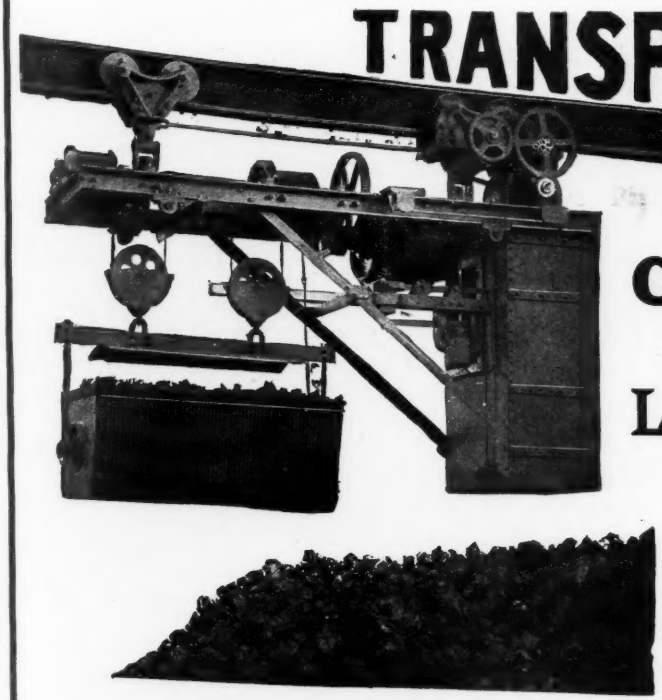


Coal and Coke

etc., etc.

Large Installations

now

at work and

on order.

WRITE FOR PARTICULARS TO—

W. J. JENKINS & CO., Limited,

ENGINEERS, RETFORD, NOTTS.

WILLEY & CO., LTD.,

Gas Engineers, Ironfounders, and Contractors,

LONDON & EXETER.

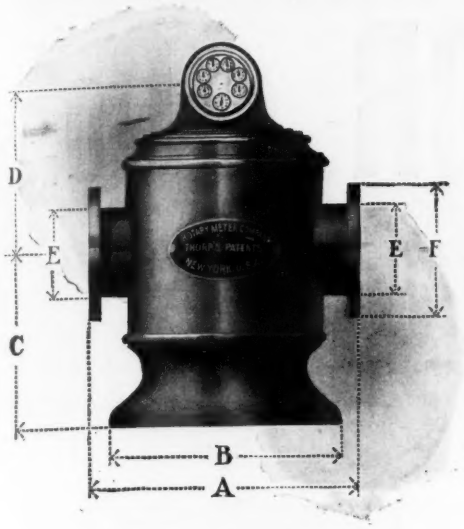
Actual Makers of every description of all

GAS PLANT AND CONSTRUCTIONAL WORK.

RETORT SETTINGS	ALL THE LATEST IMPROVEMENTS.
CONDENSERS	ATMOSPHERIC AND WATER COOLED.
LIVESEY WASHERS	ORIGINAL MAKERS.
PURIFIERS	BEST AND CHEAPEST CONSTRUCTION.
CENTRE VALVES	PICKERING'S PATENT, COMPACT, COMPLETE, CONVENIENT.
GASHOLDERS	SPIRAL AND STANDARD GUIDED.
STATION GOVERNORS	PATENT EQUILIBRIUM VALVE, PRESSURE ABSOLUTELY CONSTANT. ANY SIZE.
STATION METERS	IN CYLINDRICAL CASES TO 30,000 FEET PER HOUR, IN SQUARE CASES UP TO 200,000 FEET PER HOUR.
WET AND DRY METERS	OF THE HIGHEST EXCELLENCE IN MATERIALS AND WORKMANSHIP.
SLOT METERS	FROM 2-LT. TO 100-LT. FOR ANY COIN, POSITIVE IN ACTION, ABSOLUTELY ACCURATE, HUNDREDS OF THOUSANDS IN USE.
GAS FITTINGS AND MAIN COCKS	A SPECIALITY.
SLOT INSTALLATIONS	PIONEERS OF THE SYSTEM FOR FITTING UP SERVICES, METERS, STOVES, AND GAS-FITTINGS.

SHOW-ROOMS { London: 18, Adam Street, Adelphi, W.C.
Devonport: 93, Fore Street.

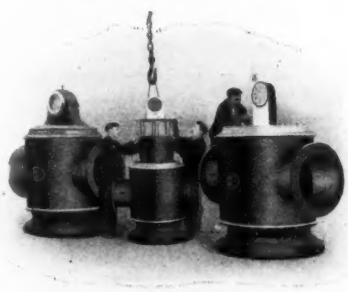
Telegrams: "WILLEY, EXETER." Telephones: 132 EXETER.
" "WILLKUEHR, LONDON." " 7495 GERRARD.



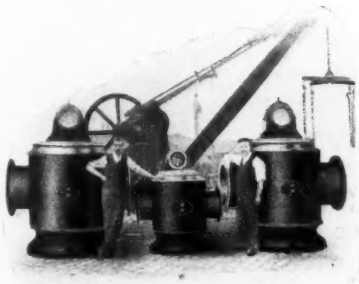
ROTARY STATION METER.
For Coal Gas, Water Gas, or mixed Coal and Water Gas.

SPECIAL METER.
For Coke Oven Gas, and Fuel Gas.

Two 60,000 cubic feet per hour and One 30,000 cubic feet per hour Meters.



Putting on the finishing touches.



Ready for shipment.

A WORLD'S RECORD

IN LARGE METERS.

Our English Works

ALONE

HAS SUPPLIED

THE

Following Station Meters.

2	for	500,000	Cubic Feet Per Hour.	
6	,,	250,000	,,	,,
9	,,	180,000	,,	,,
11	,,	100,000	,,	,,
24	,,	60,000	,,	,,
25	,,	45,000	,,	,,
42	,,	30,000	,,	,,
20	,,	20,000	,,	,,
35	,,	15,000	,,	,,
101	,,	10,000	,,	,,
19	,,	7,500	,,	,,
112	,,	5,000	,,	,,
31	,,	3,500	,,	,,
146	,,	1,500	,,	,,
30	,,	750	,,	,,

THE ROTARY METER COMPANY, of NEW YORK,

HAS ALSO MADE A

RECORD THIS YEAR.

YOUR ORDERS OR ENQUIRIES SOLICITED.

T. G. MARSH,

28, Deansgate,

MANCHESTER.

Telegrams—
"ROTARY, MANCHESTER."

Telephone—
5029 CITY.

JOSEPH TAYLOR & Co.,

Central Plumbing Works,

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CENTRIFUGALS & SULPHATE CONVEYORS.

Modern Methods.

OVER 320 SATURATORS DELIVERED.

Repairs a Speciality.

SEE FACING PAGE.

Telegrams:
"SATURATORS, BOLTON."

Telephones:
Nos. 848 and 119.

Saturator Supplied to the Sunderland Gas Company, Sept. 1899.

STILL IN.

Saturator supplied to above Company in 1907.

Exactly similar one in Building for The Consett Iron Company, Ltd., for their Coke-Oven Plant.

WILLIAMSON, CLIFF, LTD.,

MANUFACTURERS OF

BRICKS AND RETORTS

To withstand abrasion, to radiate heat, or to take exceptional Fire.
The most modern Equipment.
Make impartial Tests and specify our Products.

WILLIAMSON, CLIFF, LTD., STAMFORD.

FOR POLISHING AND CLEANING

GAS COOKERS

AND

BRASS GAS FITTINGS

WRITE TO

W. CANNING & Co.,

BIRMINGHAM,

OR ST. JOHN'S SQUARE, CLERKENWELL, LONDON,
for Catalogue "G4."

Actual Manufacturers of Machinery and Materials for Polishing and Lacquering.

Our Goods are used by all the Leading Manufacturers. Goods Specially Packed for Export.

HOLMSIDE GAS COALS.

LABORATORY ANALYSIS: By Messrs. J. & H. S. Pattinson.

Yield of Gas per ton ..	**10,500 Cubic Feet.**	**Illuminating Value expressed in Sperm** ..	**612 lbs. per ton.**
Illuminating Power	**17 Standard Sperm Candles.**	**Coke**	**68·8 per cent.**
	Volatile Matters		**31·2 per cent.**

HOLMSIDE GAS COALS are supplied to the principal Gas Companies at Home and Abroad, the daily produce being about **5500 tons.** These Coals are well-known to be amongst the best produced in the County of Durham, and are shipped on the River Tyne in Tyne Dock, and at Dunston Staiths; also at North and South Docks, Sunderland.

SOUTH MOOR PELTON GAS COALS

Are of equal quality to the "Holmside" Coal and are also largely used by Gas Companies at Home and Abroad. They are shipped in Tyne Dock, and Dunston Staiths; and at North and South Docks, Sunderland.

Both descriptions can be bought through the principal Merchants in England, or from

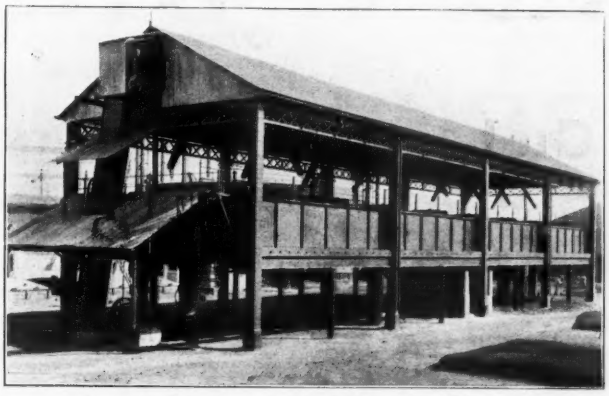
MR. MARK ARCHER, HOLMSIDE AND SOUTH MOOR OFFICES, NEWCASTLE-UPON-TYNE

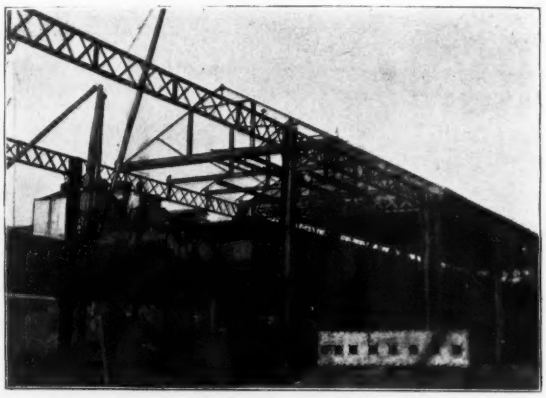
From whom copies of Analysis and further Particulars may be obtained.

FACTS THAT SPEAK FOR THEMSELVES

1904.

We Manufactured and Erected these Purifiers, which are 30 ft. square, together with the Steel Structure, Roof, and Oxide Handling Plant.



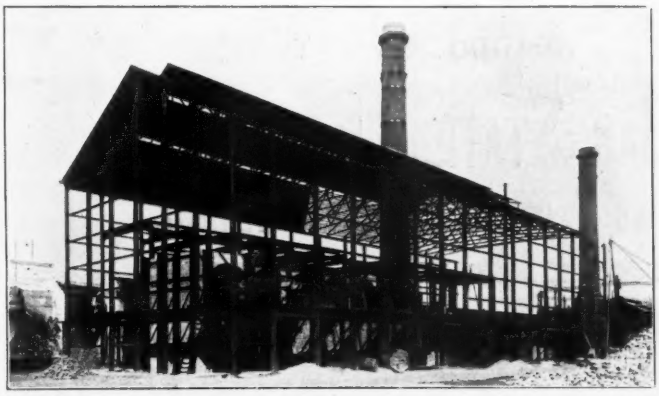


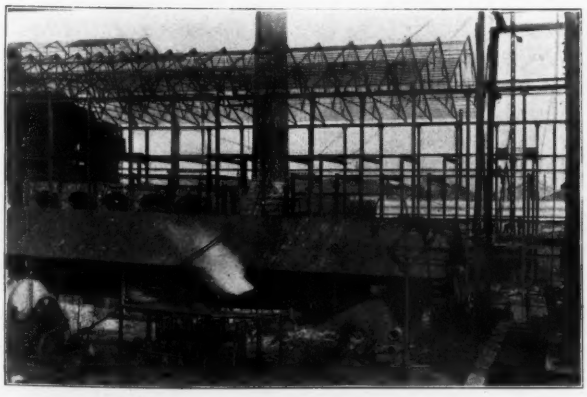
1910.

We have just extended the above Plant by adding 4 more Purifiers, 40 ft. × 30 ft. with Structure, Roof, and Oxide Plant. This illustration shows the work in course of erection.

1908.

We Supplied and Erected this Steel Retort House and Roof. The Building was arranged for 12 Through Beds of 8 Retorts 20 ft. long, six of which we built complete with Ironwork and Coal Handling Machinery.





1910.

We completed the remaining 6 Beds in the House shown above.

We have also just Erected a similar Retort House and Roof with 10 Through Beds of 8 Retorts, 20 ft. long, with Ironwork and Coal Handling Machinery complete. This photo was taken during the erection of the Plant.

DRAKES LIMITED, HALIFAX.

J. & J. BRADDOCK

(BRANCH OF METERS LIMITED),

Globe Meter Works, OLDHAM.

Telegrams: "BRADDOCK, OLDHAM." National Telephone No. 815.

AND 45 & 47, WESTMINSTER BRIDGE ROAD, LONDON, S.E.

Telegrams: "METRIQUE, LONDON." Telephone No. 2412 HOP.

Braddock's Patent

PREPAYMENT METERS.

WITH CHANGE WHEELS OR SELF-CONTAINED PRICE CHANGERS.

See our Descriptive Sheets.

Fitted with Colson's Patent Cash Boxes when required.

BRADDOCK'S PATENT

GAS STATION GOVERNORS

MOST COMPACT AND CONVENIENT.

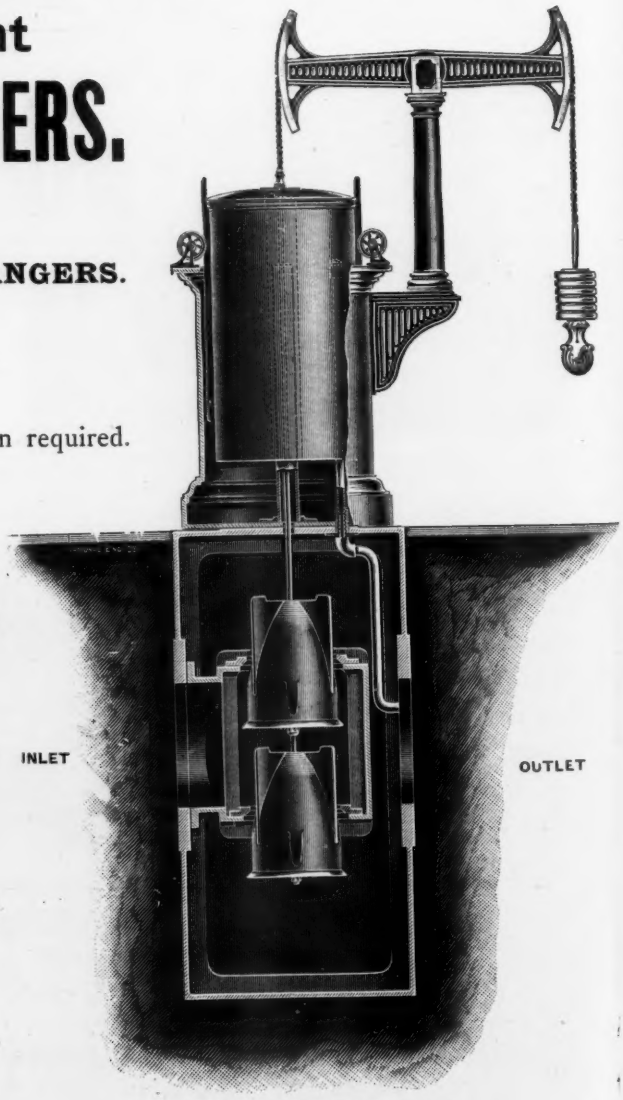
EXTENSIVELY USED.

BRADDOCK'S ENCLOSED

RETORT-HOUSE GOVERNORS

ARE UNSURPASSED.

See our Illustrated Sheets for Further Particulars.



GOVERNOR, No. 190 Type.

IMPROVED GAS STATION METERS

(OF ALL CAPACITIES UP TO 300,000 CUBIC FEET PER HOUR).

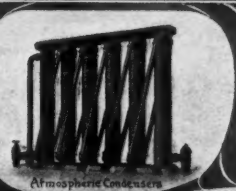
OF SUPERIOR QUALITY AND CONSTRUCTION. ABSOLUTELY RELIABLE.

SUBSTANTIALLY MADE. BEST VALUE OBTAINABLE.

C. & W. WALKER, LTD.

Hydraulic Main Valves

Lifting Cranes

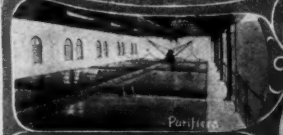

Atmospheric Condensers

Disc Valves

Steel Framed Buildings

Purifying Machines

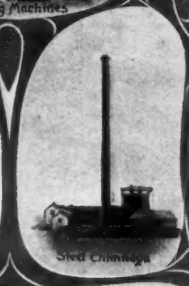
Oil Storage Tanks


Purifiers

Purifiers

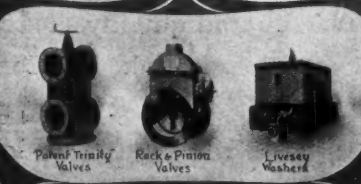
Gasholders Spiral Guided

Scrubbers


Steel Chimneys

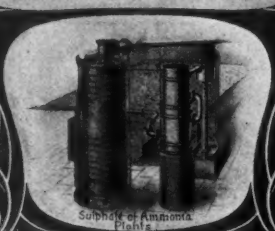
Gasholders Guide Framed

Gasholders in Brick Tanks


Patent Trinity Valves
Rack & Pinion Valves
Liversey Washers

Water Tank

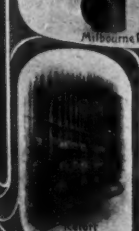
Patent Cast Iron Cover Fastener


Sulphate of Ammonia Plants

Milbourne Patent Purifier Valves

Milbourne Patent Valves

Tar Recovery Plants


Mountings

Leadwork & Saturators

Purifier Houses

Coal & Ore Bunkers

Water Tube Condensers

TELEPHONE NOS.
12, WELLINGTON, SALOP.
7638, LONDON WALL.

Midland Iron Works,
DONNINGTON, Near Newport, SHROPSHIRE.

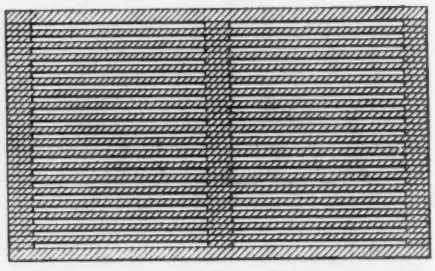
TELEGRAPHIC ADDRESSES
"FORTRESS,
DONNINGTON, SALOP."
"FORTRESS, LONDON."

J. HAWLEY & SONS,

Manufacturers of **WOOD SIEVES FOR GAS PURIFIERS,**

WITH PATENT SQUARE IRON BOLTS.

MADE BY SPECIAL MACHINERY.



BOARD FILLING IN SECTIONS FOR SCRUBBERS.

Grid Works, PENISTONE.

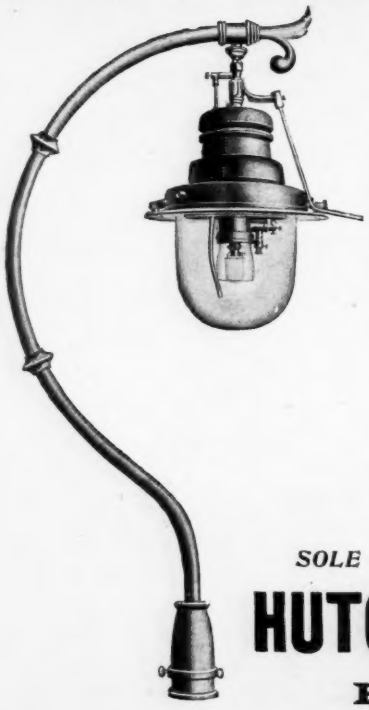
PRICES ON APPLICATION.

The "FALCON"

IMPROVED STORM PROOF INVERTED LAMP

WITH

ADAPTOR FOR COLUMN.



The best Lamp on the Market.
Made of Solid Cast Aluminium.
Gives excellent distribution of Light.
Shadowless.
Easily and quickly cleaned.
Very low in upkeep, Mantles lasting Three Months.
Made in 1, 2, 3, & 4 Light sizes.
Can be fitted with Automatic Controllers.

SOLE MAKERS:

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Falcon Works, BARNSLEY.

N.B.

MOBBERLEY & PERRY, LTD.,

Gas Retort, Fire-Clay, Red and Blue Brick Works,

STOURBRIDGE,

Manufacture best quality only of every description of Inclined, Horizontal, and Segment Retorts, Lumps, Blocks, Water-Gas Blocks, and Checker Bricks.

AN "ALL-BRITISH" MANTLE

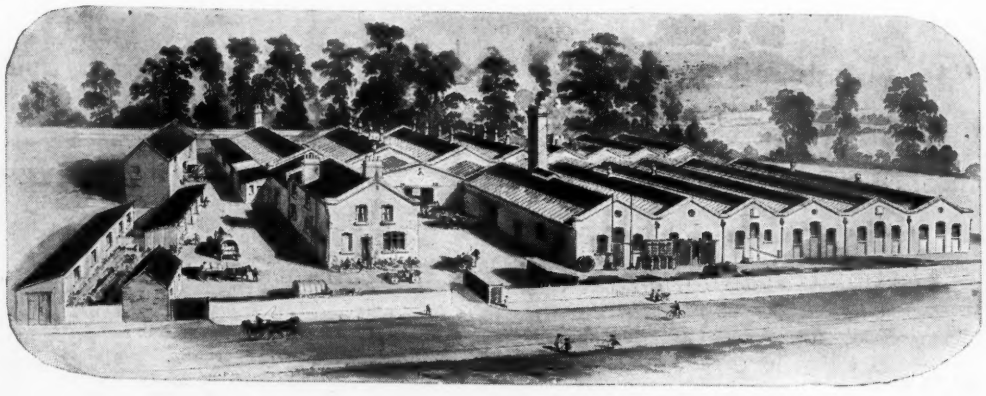
A NEW IDEA—STANDS ALONE—A BRIGHT IDEA

LOOKS WELL.
EASY TO ADJUST
NO FORK REQUIRED.
FITS ANY "C" BURNER.
RADIANT LIGHT.
LONGER LIFE.
IMPROVED APPEARANCE.

LASTS WELL.
UPRIGHT POSITION.
FOR "C" BURNERS.
EASY TO ADJUST.
USES LESS GAS.
STRONG & DURABLE.
IMPROVED LIGHT.

PATENT No. 5273/08.

ASK YOUR FACTOR FOR IT.



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JOSEPH T. ROBIN,

Mantle Works, Greyhound Lane, STREATHAM, S.W.

Gibbons & Masters'
"A.B.C." REGENERATOR SETTINGS.

Three Times the Quantity of Coal Carbonized Daily over any other System on the Market.

Guest-Gibbons Charging & Pushing Machine

Places 16 to 17 cwt. in the Retorts at One Operation, perfectly Light and Level, and without any possible risk of becoming jammed in the Retorts.

With these combined advantages we will undertake, on large Installations, to find all LABOUR from Coal Elevator Boot to Coke Yard at

PER 1/- TON

to include all Repairs and Renewals to Retort Bench and Machine for 7, 10, or 20 Years.

INCREASED MAKE OF GAS AND COKE ENSURED.

Estimates given for all classes of Ironwork and Elevating and Conveying Machinery.

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Westminster, S.W.

MANCHESTER OFFICE:
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Corporation Street.

LONDON—
142-3, Palace Chambers,
Westminster, S.W.

Telegraphic Address:
"MACHINE LOWER GORNAL."
Telephone: No. 10, DUDLEY.

MANCHESTER—
85, Trevelyan Buildings
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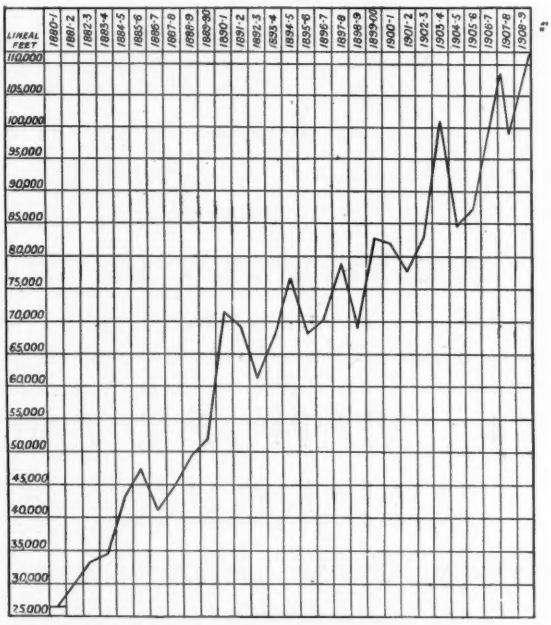
B. GIBBONS, JUNR.
LIMITED.

THE LARGEST MANUFACTURERS
— OF —
GAS RETORTS
(Horizontal, Inclined, and Vertical, all Made by Patent Machinery)
IN THE WORLD,

We have always endeavoured to satisfy our customers by improving the quality of our material, and the adjoining diagram shows that a steady increase of business has resulted.

We fully realise the further strain that is being put on this material through heavy charges, pushing-out machines, and higher heats, and we are determined to produce Retorts of the highest possible quality, which, we venture to think, will excel all others in refractoriness and durability.



With this in view we have appointed **Dr. Lessing, of London,** to assist us in making further scientific experiments, and we shall, with every confidence, place our material on the market as being the best obtainable.

This will necessarily **increase the cost,** but we are convinced that our customers will be amply repaid in getting a **Retort** which will give a longer life and better carbonizing results.

All Descriptions of

FIRE-CLAY GOODS,

INCLUDING

SPECIAL TILES for GENERATOR and REGENERATOR RETORT SETTINGS.

(*Every well-known system of above made by us.*)

E.P.C. "INSPECTION" Covers and Seating Blocks
FOR ALL KINDS OF BOILERS.
NOTE.—By using the above, Boilers can be Prepared for Inspection at a Cost of **4d.** each.

SPECIAL FIREBRICKS FOR PRODUCER GAS AND WATER-GAS PLANTS.
Also for the Construction of Furnaces for Annealing, Enamelling, etc., etc.

RABBETTED and PLAIN TILES, STAYS, SIGHT BOXES, HAND-MOULDED and PRESSED BRICKS, etc., etc.

HEAD OFFICE: DIBDALE WORKS, DUDLEY.

STREET LIGHTING
Conversions

Inverted Adaptations to Fit any Size Lantern.

MAXIMUM LIGHT
FOR A
MINIMUM CONSUMPTION.

ANGLE BURNERS.

NO INNER CHIMNEYS OR
GLOBES REQUIRED.

Samples for Trial on Application.

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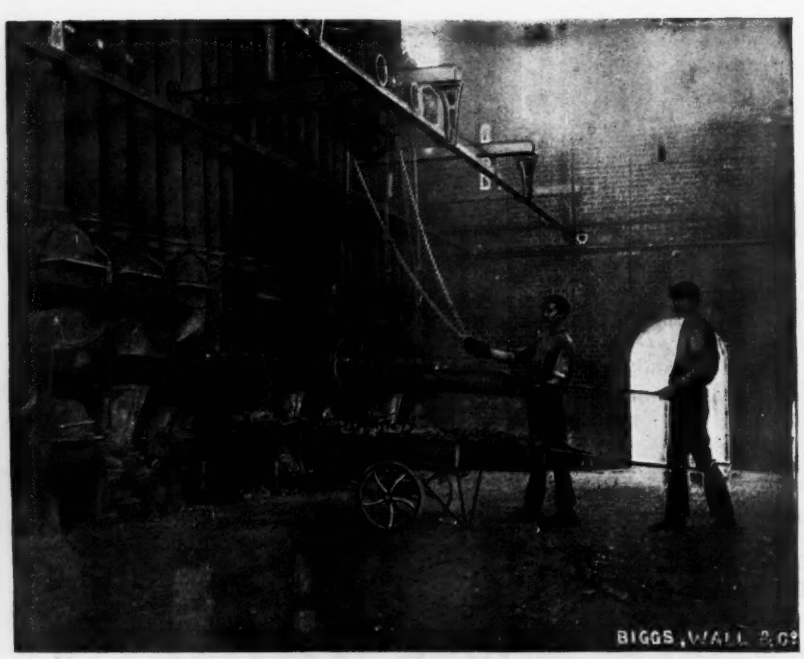
MOFFAT'S LIMITED,
13, FARRINGDON ROAD, LONDON, E.C.

"RAPID" MANUAL AND POWER CHARGING MACHINES.

SIMPLE AND INEXPENSIVE.



"RAPID" MANUAL CHARGER AND SCOOP CARRIAGE WORKING AT BRENTWOOD GAS-WORKS, ESSEX.

INCREASED YIELD OF GAS and REDUCTION OF FUEL CONSUMPTION.

WRITE FOR PARTICULARS
to

BIGGS, WALL & Co.,
Gas Engineers,
13, CROSS STREET, FINSBURY, E.C., LONDON.

Also for name of Works where you can see Machines in operation.

GAZINE

(Registered in England and Abroad.)

A Radical Solvent and Preventative of Naphthalene Deposits, and for the Automatic Cleaning of Mains and Services. It is used also for the Enrichment of Gas.

SUPPLIED BY

C. BOURNE

West Moor Chemical Works,

KILLINGWORTH,

OR THROUGH HIS AGENT:

F. J. NICOL,

PILGRIM HOUSE, NEWCASTLE-ON-TYNE.

Telegrams: "DORIC NEWCASTLE-ON-TYNE."
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FENLON'S & SHREWSBURY'S

**GEYSERS,
AS BATHS,
AS BOILERS,
AS RADIATORS,
AS CIRCULATORS,
AS FIRE BURNERS,
REENHOUSE HEATERS**

possess advantages contained by no other make.

FENLON'S
"C.C. Fleet"
CIRCULATOR
with
THERMOSTATIC VALVE.

Distinctive Point:— An important and distinctive feature is the Clearing Plugs (as shown in illustration), by means of which all deposit of fur, &c., can be easily removed.

We shall be pleased to send a sample of Our Circulator for you to test alongside the one you are now using.

Please write for Catalogue "No. 27," and discounts, containing full particulars of our specialities.

May we send you a Supply of our Booklets?

FENLON & SON (Incorporating G. Shrewsbury & Co.),
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WELLS' "LIGHTNING" PAINTER

SUPPLIED TO 12 GOVERNMENTS, PRINCIPAL RAILWAYS, AND LEADING GAS WORKS AND FIRMS IN GREAT BRITAIN.

(WALLWORK AND WELLS' PATENTS).

PAINTING BY MACHINE.

Great Saving of Time, Paint, and Labour,

Painting Speed—3 Square Yards a Minute.

The paint is sprayed evenly and continuously through a flexible tube and nozzle supplied with compressed air, either from existing air main or from our special Compressors.

	£	s.
No. 1 Painter	25	0
No. 2 ,,	30	0
No. 3 ,,	35	0
Single Air Compressor	17	10
Double Air Compressor	27	0

Wells' "Lightning"

LIME AND COLOUR WASHER.

A Great Saving of **Time, Labour, and Money.**

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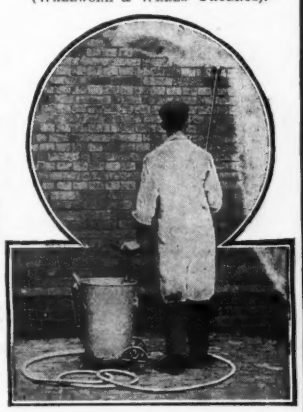
NO OUTSIDE POWER REQUIRED.

Saves its Cost in a Few Days.

Over 4000 Sold.

Lime, Whiting, or Cold Water Paints

applied at a speed of from 10 to 20 square yards per minute, in a manner superior to brushwork. One coat with the machine on rough surfaces is equal to two applied with brushes. The material is applied in the form of a spray, and is driven into corners and difficult places where a brush would not reach.



	£	s.
No. 6 (no tank), on wheels, fed from pail	7	7
No. 6A, with detachable pail	5	15
No. 4, capacity 6 gallons ..	8	10
No. 4A, on wheels, same capacity as No. 4	9	10
No. 5, Large Size, capacity 10 gallons	10	10
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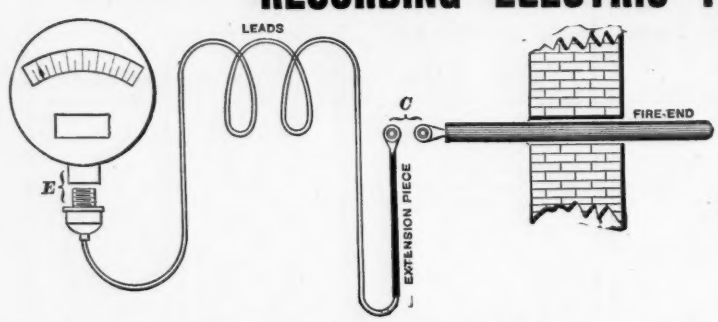

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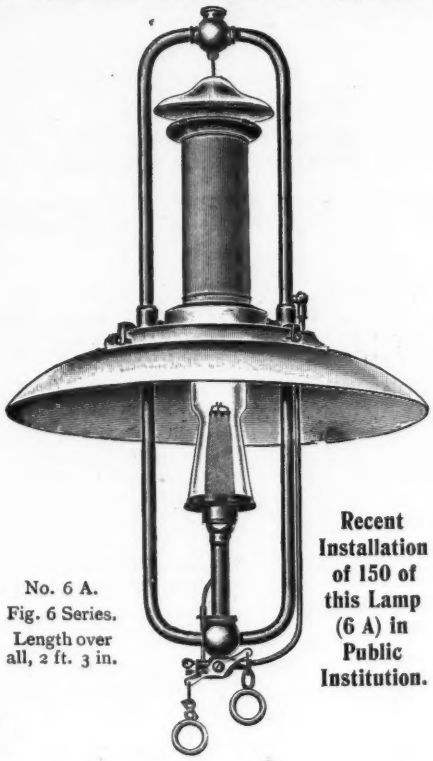

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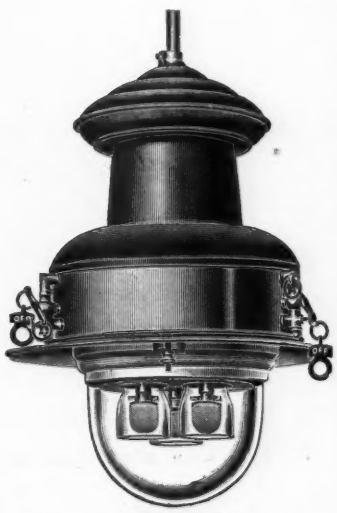

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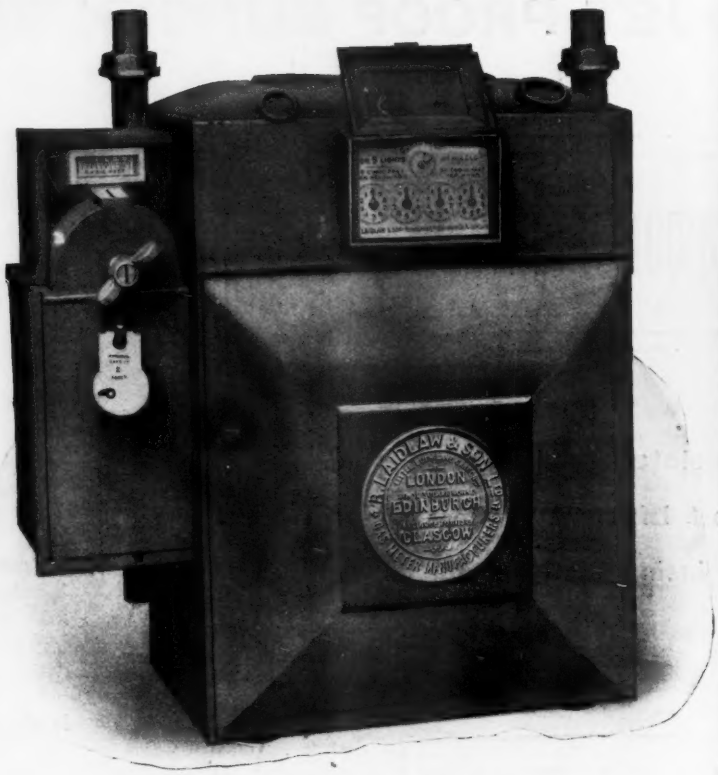

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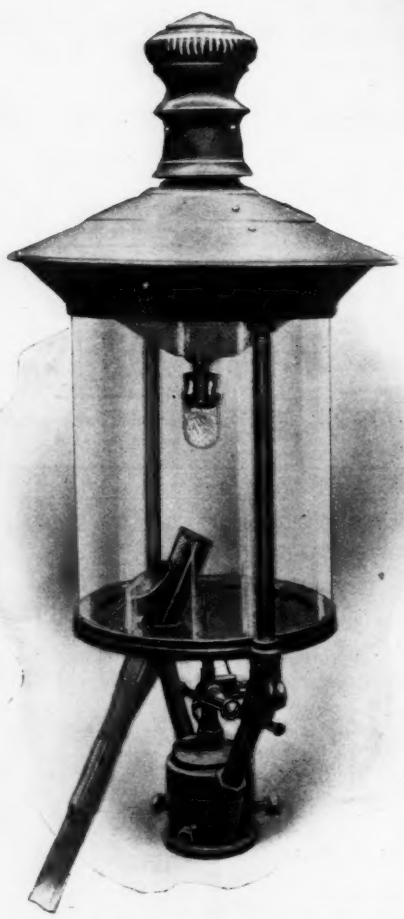

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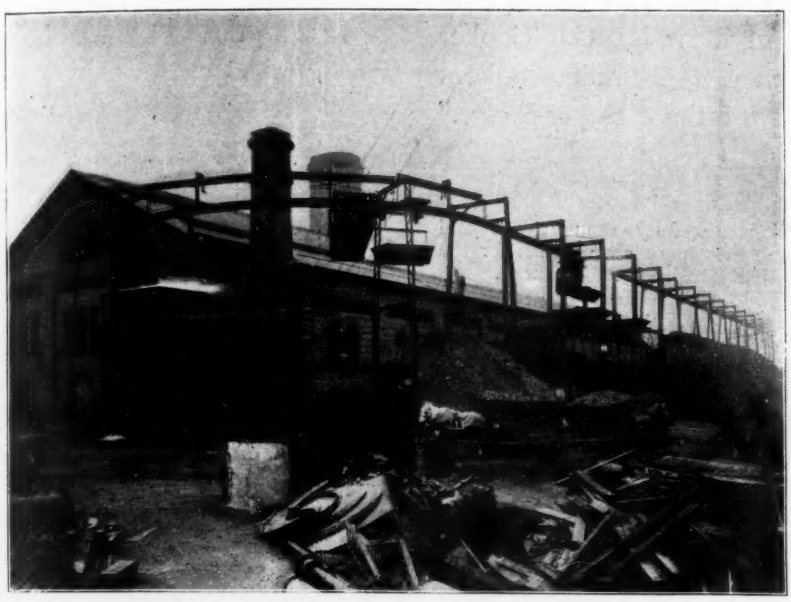

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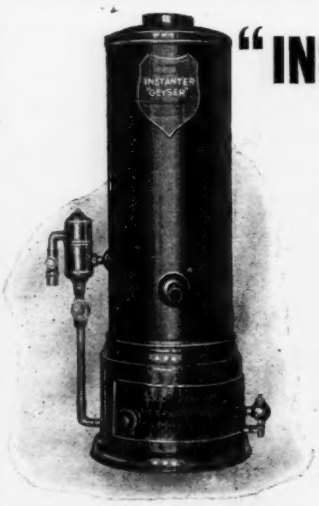

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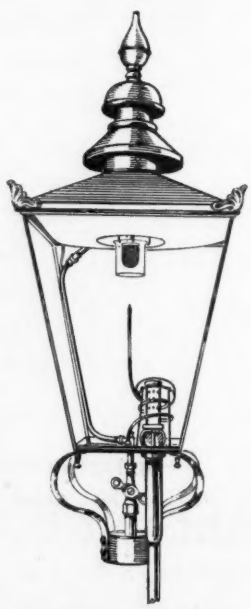

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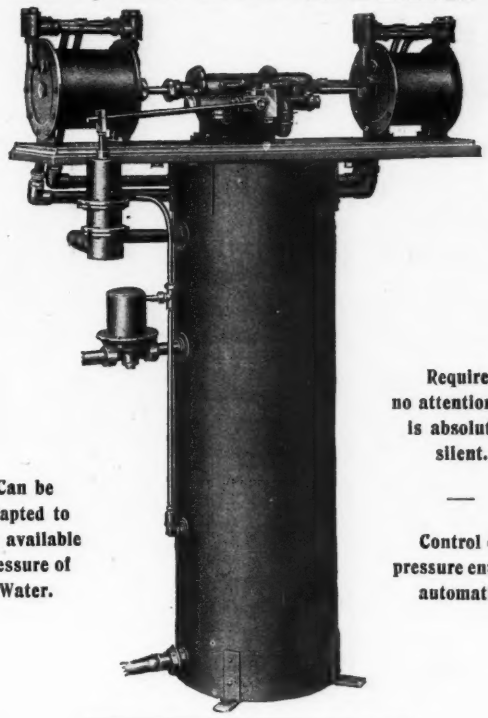

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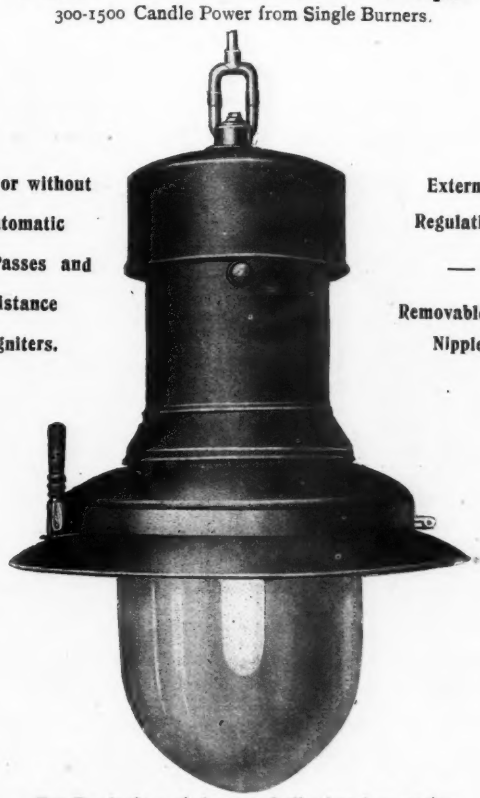

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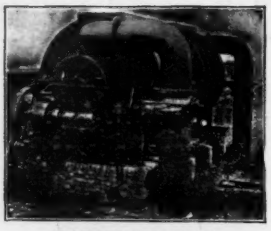

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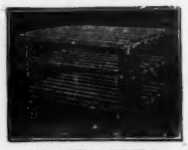

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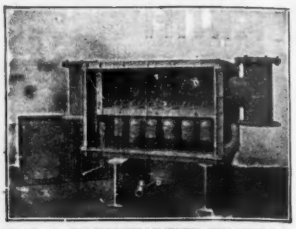

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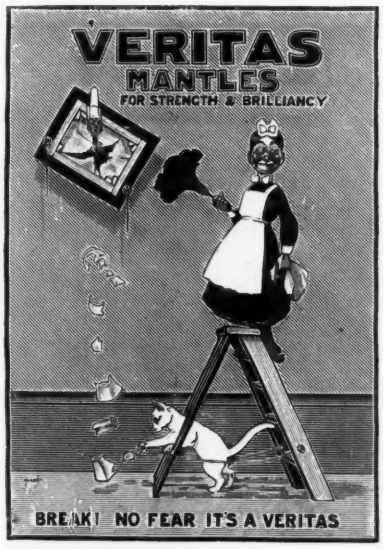

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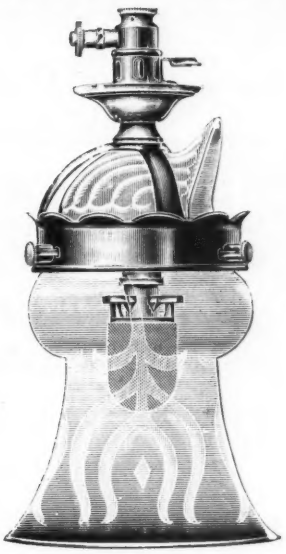

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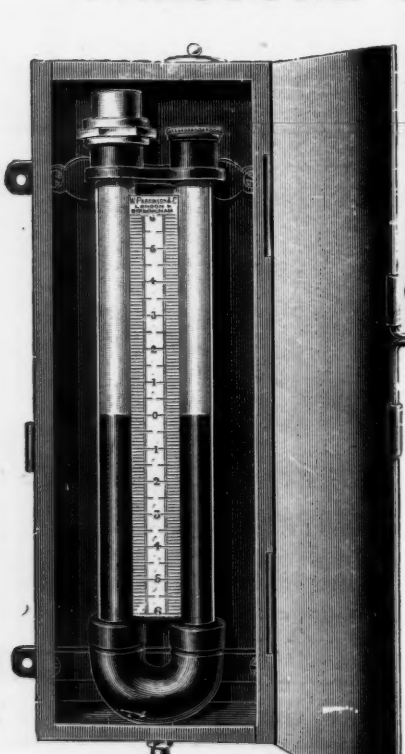

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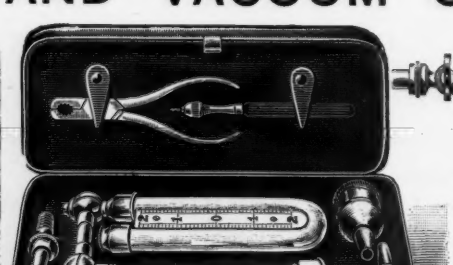

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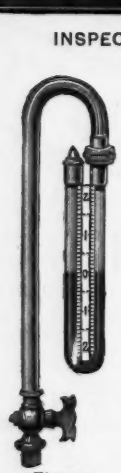
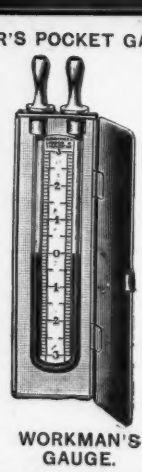


Fig. 6.



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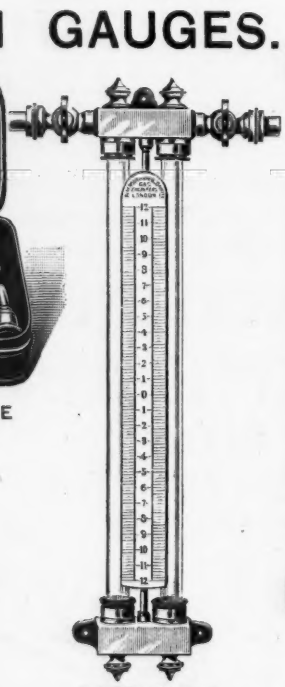

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Fig. 5B.

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EDITORIAL NOTES - GAS, &c.

The Institution Meeting.

THE year of the occupancy of the presidential chair of the Institution of Gas Engineers by Mr. James W. Helps has been brought to a close by a meeting that will take position as somewhat extraordinary in regard to the value and the suggestiveness of the material parts—composed of both commercial and technical subjects—of the proceedings. The value of any particular subject in such an industry as ours must be appraised not only in regard to its rank in technical operations and commercial procedure, but in respect of its current importance; and if we reflect on the proceedings of last week, it will be conceded that, from beginning to end, there was an exceptional current pertinence about them all. No such meeting has any value unless it projects some influences into the future; and we do honestly believe that from this meeting in many ways—in connection with manufacturing operations, the gas supplied, commercial methods, co-operation, and the improvement of the means of utilizing gas for heating—there will arise considerable advantage in the future. As we said last year, so we may say again this, a change in tone has come over the meetings of the Institution; and this is to be traced, in our opinion, to the attraction to its platform of men who have the time and ability to pursue investigation under the surfaces where, through the pressure of responsibility, which increases and does not diminish in any direction, the technical officers of the industry have to be largely content to labour. But at the same time, it is palpable that the influence of association, of the infusion of new ideas, and of the practical application of derived knowledge, are in many ways elevating discussion, examination, and deduction.

No small meed of praise for the success of the meeting must also be given to the President. Those well-known traits of his—acumen, courtesy, and business aptitude—did much in carrying through an extensive programme without undue pressure being in any part apparent. The weather, too, was kindly disposed, and played a no small part in the enjoyment of the week. To the Chairman and Directors of the Croydon Gas Company, whose kindness on Friday completely captivated the members and their ladies, the fullest acknowledgment must likewise be expressed. They spared nothing to enforce the pleasure that it gave them to receive those who had raised Mr. Helps to the seat of the greatest honour among them. And the President himself would but desire that, in the distribution of these acknowledgments, sight should not be lost of the loyal assistance rendered him by the Hon. Secretary (Mr. S. Y. Shoubridge), and the Secretary, Mr. Walter T. Dunn.

A new presidential year has commenced its course; and to Mr. Alex. Wilson we express the hope that his year of office may be such that it will give him at its close the liveliest sense of gratification, and the knowledge that the work accomplished has added a chapter of the highest importance to the history of the gas industry. Of this we may be sure, that conscientious effort will not be wanting on his part. The meeting just closed shows much work that is lying at hand, awaiting further attention.

A Message to the Gas Industry— An Extended Central Organization.

THE year of Mr. Helps's presidency has been made memorable by an address of extraordinary value, treating as it does of matters of immediate and vital moment to the gas-supply industry as a whole. The chief subject in the composition transcends, in current importance, all matters of technical character. He had a message to deliver. He delivered it; and it was evident that, in doing so, he was conscious of the responsibility. The message was the outcome of a calm and judicial survey of the present position of the industry, and of a perspective scrutiny of its affairs. The address is full of perception, warning, impeachment, and of desire to create an organization concretely representative of the industry for prosecuting work designed, through real and perennial activity, to solidify its defences, and to advance generally its interests. Throughout, the deliverance palpitated with the fervour of one strong in conviction, and in the righteousness and the wisdom of the cause in hand. The President, however, wished what he had to say to be detached from the individual, and from the representative of any particular gas undertaking; and for it to be taken as coming from the, for the time being, titular head, and therefore from the mouthpiece, of the leading executive branch of the gas industry. But the honour must remain largely a personal one. The message, let it be added here, is addressed to a much larger circle than the technical representatives of the industry. If we omit the portion that is interjected—and seems a little out of place through the breaking in upon the continuity of thought—between the statement of the changed conditions of the industry and the case as to the necessity for extension from technical to industrial representation of the constituents of the chief organization of the industry, there is not a line or a word that should not receive careful and thoughtful consideration by all concerned, in any directive or official part, in the fortunes of the business of gas supply.

All around us in the industry changes are taking place; and the President points to some of the leading ones, and to their meaning. The conditions of the past are buried far beneath the circumstances of the present. In the technical methods governing production, there has been change, and change is still proceeding. Important as that is, the President did not—and perhaps advisedly—lay much stress upon it on the present occasion. It is beyond the techical ground that the plea for the necessity for a new order of central representation and organization finds its best foundation, inasmuch as it is the foundation that is most intelligible to those among whom it is essential that the plea shall find favour. We have to get outside the board-room and the gas-works gates, to obtain a proper view of the position. What is seen there? The uses of gas have changed and expanded. More economical methods and more scientific methods of utilization have taken the place of the crude methods of yore. To obtain and retain the satisfaction of the consumers, more expert attention is required by the means of utilization. Men need to be specially trained for this work. The economy, the still advancing economy, of our means of utilization has to be compensated by new business. New business is more difficult to obtain in these days when the fields of opportunity—broad though they be—are occupied by active and strong competitors. It is to the disadvantage of the gas industry, too, that electrical competition is largely directed by municipal agency—an agency that (in electrical departments at any rate) is arbitrary in its methods, and unrestrained by the rule of personal responsibility and self-interest. Briefly put, but not by any means comprehensive of all change, that is the position outside the works, where the methods employed make for prosperity or the reverse.

The old practices and the old methods have been put into the balance, and have been found wanting; but there are still many who try to make them fit the altered circumstances. The act is absurd, and the result is not pleasant; and the day will assuredly come when such administrators will rue their shortsightedness, or whatever else it may be that has caused them to hold back from shaping their modes of operation to the altered needs. Even the best of managements would do well to have a little introspection, and to ask themselves whether what they are doing in their own locality is sufficient for their own undertaking and for the common advancement of the industry. Though we boast in the gas industry of free intercourse, there still exists a goodly amount of exclusivism, which need not continue in

an industry that is, in its prime commodity, internally non-competitive. Therefore what the President asks is (and it is a question that has been put before in these pages), Is enough being done in the industry in co-operative work for the general good? We cannot imagine anyone coming to any other finding than the negative. That must be changed; and to effect it there has to be inculcated in the ranks of the administrative portion of the industry a sense of community of interest. If this can be accomplished, the rest should be plain sailing. If, however, we cannot bring this about from within, then sooner or later, the pressure of a callous competition will certainly effect the same end. Accepting the doctrine of community of interest, it will be readily seen, in all places in the industry, how much there is to be done that can only be effected by co-operation. The free discussion of methods and practices, and persevering and continuous work in many ways for common defence and progress—in connection, for instance, with competition, by free advertising in the daily papers, by popular articles that will be both instructive and corrective of misstatements from other quarters, and by systematic watching and activity—will be, and cannot fail to be, mutually advantageous. Some of these were questions that were discussed at the meeting held under the auspices of the Commercial Sections of the District Associations on Tuesday afternoon; but they are matters that, while temporarily dealt with in some way, should be considered in relation with the larger scheme propounded by the President.

To carry out all such work, and much other both definite and casual (such as has marked the history of the industry during recent years), there must be a proper, effective, and strongly-supported central organization. Is the Institution of Gas Engineers such an organization? Is it representative of the whole of the interests of the gas-supply industry? The President, and all who consider the subject in a broad-minded and judicial spirit, can only, unfortunately, answer "No." We ask every reader to consider the matter for himself. The address contains much apothegm and suggestive thought that will contribute to serious reflection and determination on the question. The Institution, as an effective organization representative of the gas-supply industry as a whole, stands condemned by the smallness of its yield; and by the substantial proof of its circumscribed activity. The President submits that the cure for this is an extended constitution of the Institution. He commits himself to nothing as to exactly what should be done; but he takes his stand firmly on his personal convictions as to present needs and present woful inadequacy of both method and organization. What he says beyond is purely suggestive, and subject to revision upon judgment from collective deliberation and wisdom. He offers alternative proposals as the first steps to the end in view: (1) The alteration of the Articles of Association of the Institution, so as to allow of the admission of officials who are now strictly ineligible (the chiefs of secretarial and distribution departments), and to keep to the present title of the Institution, which would be a misnomer; or (2) to revert to the title of "The Gas Institute," and to divide the work into sections, in much the same way as is done by the British Association. The latter is the course favoured by the President; and with him we think the gas industry will generally agree. It is a broadening of the basis of the central organization that is first required; and the broader it is made (subject to regulation in order to avoid indiscriminate election) so as to give future liberty, in place of the present crippling restriction, the better. With sectional work, any feared unwieldiness would not be felt.

As a matter of fact, the want, in the President's opinion, is a numerically strong body, thoroughly representative of the various interests concerned, and therefore particularly well calculated to secure the co-operation of the various officials of gas undertakings, and the confidence and financial support of the companies and local authorities they serve. But regarding the limitation that the President sets on the directions in which the numerically strong body representative of all interests is to be obtained, there may be some divergence of view. He confines himself to the naming of the heads of the secretarial and distribution departments. In our opinion, that is where he errs. By such restriction, the financial interests of the gas-supply industry are not secured an adequate direct representation. That apart, too, the greatest curb upon its movements in effective and more extensive work the Institution has had, has been its comparatively penurious condition. A much stronger financial position must be secured. That stronger position is wanted more than ever; and the subscriptions of an increased number of members from the ranks of gas officials will not alone produce this. And where gas engineers have failed to produce an adequate financing of the work of the central organization, the heads of the secretarial and the distribution departments cannot surely be expected to do better. The President admits that boards of directors and committees of gas undertakings must have the assurance that the body or Institution which sets itself the task of carrying on any organized work is thoroughly representative of the various interests of their several concerns. Only in this way, he adds, will they gain sufficient belief and confidence in the work being done on their behalf, and induce them to give to it not only their moral but their financial support.

If this is so, would not a more direct method of obtaining that confidence and moral and financial support be by inviting representation of gas undertaking administrations in both membership and direction of the central organization? It is a composite organization for the gas-supply industry that is now proposed; and confidence and other necessary things are not to be gained by keeping the real representatives of the financial interests of the industry outside the pale of the organization. The President would invite them to a conference on the subject of the need for combined action and for an extended constitution of the Institution. That is good; it is necessary. But there he stops short in his suggestion. Directors and committeemen have not only to realize and appreciate to-day, but their realization and appreciation have to be kept alive to-morrow. Their interest has to be sustained, and so has that of their successors. We know of no way in which this is to be done, except by permanent participation and identification with the work—anyway of one of the sections—of the central organization, and by representation on the central council. Confessedly, it is a difficult work that has to be tackled in this direction. Custom, prejudices, inanition, parochial tendencies, parsimony (for the development of which the long unchallenged security enjoyed by the industry is responsible) are obstacles that have to be removed; and until they are, the officials of the industry will never be accompanied by united lines of administrators on to the path of practical wisdom to which direction is given by the changed conditions.

This matter must not remain where the President has left it. His address must be the turning-point to the construction of stronger defences, and to the broadening of activities in the common interest. Acting on the suggestion made, the Council have received an instruction to appoint a Special Committee to consider the whole matter and to report. We hope that the Committee appointed will be a composite one representing not only the engineering side of gas-supply industry, but the administrative, the secretarial, and the distribution sections. But this work should be pushed forward, independent of the annual meetings. It is indeed a work—a great work—worthy of the utmost despatch and effort. The truth has been plainly written by the President. Appreciation of it not only by officials but by directors and committeemen, and the realization of a strong centre—a veritable centre of co-operative activity—should be easy of attainment.

Fresh Starting-Points for Research and Application of Knowledge.

JUDGMENT before the event is never wise or safe. When the programme for the annual meeting was first issued, there were freely expressed views that there would be comparatively little in the papers that would evoke discussion; but now that the meeting is over, the universal judgment is that the prepared contributions have elicited much that is of immense value to the gas industry, and that new starting-points for research and action have been marked. Take as a group first the statement on heavy-charge working by Mr. J. Ferguson Bell in connection with the Carbonization Committee's report, Dr. Davidson's paper on the Birmingham coal-testing plant, the report submitted by Mr. F. W. Bywater on behalf of the Refractory Materials Committee, Mr. J. B. Klumpp's paper on calorimetry, and Mr. S. Y. Shoubridge's contribution on coke-conveying; and from all these, including the discussions, there are new starting-points presented for research or for extended application of knowledge already derived from experience.

The fact is irresistible nowadays that the heavy or full

charge is a right and most productive practice in carbonization. There are a few who still endeavour to persuade themselves to the contrary; but they are one by one coming into line, and must do so if they do not wish their old reputations for good working to sink under the results achieved by others. With heavy charges, it is proved extensively—the South Metropolitan Gas Company's experience covering a million tons of coal (referred to in the carbonizing discussion by Mr. Charles Carpenter), may be taken as an example—that high yields of gas are not incompatible with good candle and calorific power. Some few have wondered, but even that few have not stopped to seriously inquire, how this is, or whence comes the increased yield without any very great depreciation of qualities. The point has been raised at this meeting; but even among those experts who have given thought to the matter, there is no settled view. There is one opinion in one place; and another in another. Both may be correct; and the increased product from the ton of coal may be due to the combination of the suggested causes. There is here a starting-point for research. We have Dr. Colman expressing the view that the steam formed from the coal in carbonization is decomposed to a greater extent with the full charge than when a large free space is left in the retort. The theory on first blush seems feasible; until Mr. Charles Hunt points out that, with a full retort, a larger quantity of virgin liquor is obtained than with a partially filled one. Under this circumstance, what becomes of Dr. Colman's theory? Mr. Hunt rather thinks the increased yield of good calorific power gas and gas without its illuminating power seriously (if at all) degraded, is due to the fact that the bulk of the gas—through the reduction of temperature in the retorts brought about by heavy or full charges, and the considerable, or entire, elimination of the free space—meets with a lower temperature, and so is not decomposed. The reduced carbon deposit on the retorts in which heavy charges are used indicates to Mr. Samuel Glover, Mr. J. P. Leather, and Mr. Bell that Mr. Hunt is on the right track in this matter. Weight of opinion is, therefore, rather against Dr. Colman, though no one, except Mr. Hunt, ventured to deny the accuracy of his deduction from mental consideration rather than from actual working.

High temperatures and a large free space have no doubt made between them a heavy claim both upon the gas product and the retorts themselves. They have been responsible for a considerable inequality in the matter of the strains to which the retorts are subjected; for while the temperature of the floor of a retort with a light charge has been diminished considerably on the introduction of the latter, there has been little change, comparatively speaking, in the temperature of the upper part of the retort. The heavy or full charge diminishes the great synchronous temperature inequality. Some indication as to what this inequality must have been is found in the report of the Refractory Materals Committee, where it mentions that, in the investigations, the maximum temperature pyrometrically registered in retorts was 1909° Fahr., and the minimum 1558° Fahr. But in testing the minimum temperature on the bottoms of the retorts immediately after charging, records as low as 800° Fahr. have been obtained. This being so, it may be that we shall find that the heavier charge may not only result in increased production, but by eliminating the great inequality of temperature, and consequently of strain, between the bottom and top parts of the retorts on each re-charge, there may be advantage accrue in respect of the life of the retort. The Dessau vertical retorts, in which full charges are employed, are giving an excellent account of themselves in Berlin in the matter of longevity; and we are hoping for more helpful records in this particular matter. There is a starting-point for investigation in regard to this question of the effect of large simultaneous inequalities of temperature in retorts, and the lessening of those inequalities by heavy or full charges.

Bearing upon this question of full charges, is that of calorific power. Dr. Davidson shows that it may be taken, in ordinary working, as a rough rule that a 2 per cent. reduction of illuminating power only represents 1 per cent. reduction of calorific power. But this does not apply to vertical retort and full charge working; for the calorific power under these conditions is shown to be higher than in ordinary working, though the illuminating power may be lower. It was rather noticeable, in the Presidential Address, in the discussion on Mr. Klumpp's paper, and during the discussions on carbonization, the freedom with which the setting up of a calorific power standard (appropriate to local conditions) was advocated to supersede the illuminating power ones. The matter was also introduced in connection with Mr. F. J. Ward's paper on the management of small gas undertakings; for in carrying on successfully the affairs of a small non-statutory company, the only consideration he gives to illuminating power is through the jet photometer and his optic organs, and, so long as the calorific power is satisfactory, he does not concern himself about much else. Here, again, is a starting-point. Those best competent to give a judgment as to calorific power, under the new conditions of gas use, and under the new conditions of gas production, pronounce it to be altogether a more favourable standard in the interests of consumers, and yet a more stable property of gas than illuminating power, and therefore a standard more appropriate for gas makers to which to work. The suggestion fell from Mr. Arthur Valon that the big corporations supplying gas could help enormously the gas industry by being the first to apply for the substitution of a calorific power standard for the existing illuminating power one. But care must be taken to have full regard to both general and local conditions in deciding what the standard should be. On all hands, the advocacy is that the gross, not the net, value should be adopted as the standard (for reasons set out in our "Review of the Proceedings" at the meeting, and more extensively in the full report), and that the standard itself should be fixed in each case with reference to the carbonizing system in vogue and the character of the coals generally used. These points have been made frequently in our columns; and Mr. W. J. A. Butterfield, Dr. Colman, Mr. Jacques Abady, Mr. Holgate, Mr. Klumpp, and many others who have specially studied this matter have all so advised.

There is no occasion to look far into the other papers to see where there is necessity for fresh starting-points, owing to new conditions, and the leaving behind of old practices. The fine coal-testing plant at Birmingham, and the valuable collection of results from it, that Dr. Davidson introduced to notice, lacks one provision for making tests that are of real value, through the inability to do so in conformity with the modern practice in relation to heavy charges and the rapid discharging and recharging of the retorts. Hand labour, as Mr. Carpenter pointed out, and as Dr. Davidson acknowledged, is a failing point in the plant; and this means that a complete testing plant in the future, should have, if full reliance and value are to be secured, its carbonizing portion situated in a retort-house where the operations are subject to proper mechanical control. We turn to the report presented by Mr. Bywater on behalf of the Refractory Materials Committee; and to the valuable work that it incorporates—more especially in regard to temperatures. The report opens one's eyes; and it presents a starting-point for united work on the part of makers and users. Makers of the refractory materials used in gas-works deserve in a measure pity, as well as the censure they have received. They have, as it were, been working in the dark as to requirement. This report, however, throws a considerable amount of light in that direction. It gives the makers of fire-clay goods information that they have not had before in respect of temperatures; and it shows that there must not again be the absence of co-operation there has been in the past, which has to an extent kept the practical experience of use from guiding in the production of the goods. The manufacturers have expressed, through representatives of their section of the Society of British Gas Industries, a desire to co-operate in future. One of the lessons of the inquiry has been that retorts must be made to stand not only high temperatures, but frequent and considerable variations of temperature while (as pointed out earlier in the article) in use.

Then there is the paper—the only engineering one contributed to the proceedings—by Mr. Shoubridge, and the discussion upon it. From these are gathered information as to the economy of coke-conveyors, and as to their necessity, in working of any magnitude, under the new retort-house practices. There is abundant testimony now that, if properly designed, wear and tear has been considerably modified; and that there need not be any inordinate amount of breeze produced as the result of their use. The main part of Mr. Shoubridge's paper was hardly touched upon in the discussion, and that has reference to the travelling and rising and falling transverse conveyors in conjunction with the main yard conveyor. There is a starting-point in new practice here. The transverse conveyors will really provide largely

increased storage on a given space; result in a diminution of breeze; and facilitate the loading of trucks and carts at any part of the storage ground, and on either side of the conveyor. There is no fixed point for loading as in the case of storage hoppers.

Though mentioned last here, the paper by Mr. Jacques Abady occupied (as will be seen elsewhere) first place after the Presidential Address at the meeting. It deserved it. It deals with much neglected questions; and is a studious and critical examination of public lighting contracts. Throughout it is composed of matter that is original, that stirs up thought, and that will be of immense value to all who have to deal with public lighting questions. It and the Westminster lighting contract will, we believe, together form the point at which the old ways in this matter will be left behind, and the new way advocated be adopted. The plan of purchasing illumination under photometrical protection, ignoring quality, pressure, consumption, and all such matters to which attention has hitherto been paid, appeals as a scientific one, and one that will be pushed to the front by the inexorable force of competition. But in connection with it, cost should not be the only factor for consideration; reliability and efficiency in the worst of atmospherical conditions should not be lost sight of in dealing with the question of illumination for our public streets.

Gas-Heating Research.

THE second report of the Gas-Heating Research Committee appointed by the Institution of Gas Engineers in conjunction with the University of Leeds constitutes one of the most valuable items in the technical programme of this year's meeting. It is a production which is highly creditable both to the Committee and to Mr. E. W. Smith, M.Sc., who has carried out, for the Committee, the investigations the results of which it records and discusses. These investigations have covered a great deal of ground; but from the standpoint of the practical gas man, they may conveniently be grouped under three headings—viz., (1) A comparison of the efficiencies of various makes and types of gas-stoves, and of the effect thereon of varying the gas consumption; (2) A study of the radiation from gas-flames, and from "fuels" of varying composition; and (3) An investigation of condensing gas-stoves. Incidental to the research work, it was found desirable to devise a simplification of the former mode of mounting the thermopile with a view to facilitate its transference from one position to another of the surface of the hemisphere over which the radiant heat from the stoves was determined. The simplified method of mounting effected a considerable reduction in the time occupied in the determinations, and rendered the latter more reliable than those made in connection with the first series of researches, the report of the Committee on which was presented at the previous meeting of the Institution.

In our comments on that report, we said that it was eminently desirable that researches should be pursued with the object of determining the relative radiating efficiency of the different types of gas-stove. We are glad to observe that the Committee have taken this view, and have had comparative investigations made of a number of gas-fires of different types and makes. The conclusion to which these investigations lead is that no one make of gas-stove stands out above all others as a type of what should be. "Where "one stove has an advantage in one respect, it falls short "in another." Had the conclusion been otherwise, and the Committee had reported that one make of stove was pre-eminently superior, the big commercial interests represented in the other makes would have been seriously damaged, and embittered comments on the Committee's work would almost certainly have ensued. Fortunately, the discovery that the various makes and types attained a uniformly high efficiency, though the advantageous points of each were different, will ensure a more peaceful reception being accorded to the report, and a greater measure of benefit from its conclusions accruing to the general body of makers of gas-fires, and to the gas industry at large. Disregarding the reflector type of stove, it appears that, of the total heat of the gas consumed, the proportion which is radiated varies from 35 to 43 per cent. when the various gas-fires examined are used in normal conditions. By modification of the form or composition of the "fuels," it was found possible to raise this proportion to as much as, in one case, 48·5 per cent. The Committee apparently consider that the maximum figure attainable for radiant heat efficiency with the present type of open gas-fire will be a little more than 50 per cent.—that is to say, it should be possible for the makers of gas-fires to improve them to such an extent that an average radiation at the present time of (say) 40 per cent. of the heat of the gas consumed will be raised to about 50 per cent. in the near future. This points to a substantial gain in the practical efficiency of gas-fires being realized at an early date—in fact, we believe great progress in this direction has already been made by manufacturers of gas-fires (certain claims to this effect were made during the discussion of the report at the meeting) while the Committee's investigations have been in progress.

Another interesting matter looked into by the Committee was the effect on the radiation efficiency of a gas-fire of varying the gas consumption. The result may be said to have been a foregone conclusion, since the duplex type of gas-fire owes its origin to previous recognition of the facts disclosed. With "fuel" of a particular form and dimensions, the highest radiant efficiency is secured when the gas-flame has a certain shape and size. If the consumption of gas is altered from that which affords this normal flame for the "fuel" in question, the flame is altered in size and probably in form also, and no longer fits the "fuel" well. The radiant efficiency falls as a consequence of bad fit between the flame and "fuel." But since the amount of radiated heat required in a room varies from day to day, and even from hour to hour, the gas consumption of the fire has to be varied accordingly. If all the burners are turned up or down, the gas is not burned in the altered conditions to the best advantage. In one experiment made by the Committee, a reduction of the gas rate to about one-half, effected by turning down seven burners, reduced the radiant efficiency from 37·7 to 30·7 per cent., whereas a similar reduction of the gas rate effected by turning out four of the seven burners (the remaining ones being full on) left the radiant efficiency at 36·9 per cent. This experiment demonstrates anew the well-recognized advantage in respect of efficiency and convenience that may be secured by the use of the duplex type of gas-fire.

The study of the radiation from gas-flames and from "fuels" of varying composition which has been made by the Committee has disclosed many interesting, highly suggestive, and valuable points. It was found that a gas-fire with the old type of vertical iron-frets had only about the same radiant efficiency as one of the best of the fire-clay "fuel" fires. But the iron-fret fire examined had no gas or air adjustments; and had it been the equal in this respect of the other fires, it is possible that it would have shown a higher radiant efficiency. Be this as it may, the results of the comparison show that a fire of very old design fitted with iron-frets is little, if at all, inferior in respect of radiant efficiency to the most modern pattern of fire-clay "fuel" fire. The upshot of this comparison has fully justified us in drawing attention last year to the claims of the old iron-fret fire to a high radiant efficiency. Even now, we think the iron-frets may repay further investigation, firstly, by fitting them in stoves with modern gas and air adjustments; and, secondly, by varying, in the light of modern knowledge of alloys, the composition of the "iron" from which they are cast, in order to diminish, if possible, the tendency to oxidation and increase the radiation. The radiation from bunsen and luminous flames was studied by the Committee; and a test of the radiant efficiency of a reflector stove with luminous flames was made. The result was low—only 26 per cent.; but this must not be forthwith taken to represent the efficiency of those reflector stoves which are in very general use in many Continental countries. The stove examined by the Committee was clearly not of the regenerative type; and it is to the heated air-supply and the consequent high temperature of the flames that the Continental reflector stove owes its efficiency. We are inclined to think that the latter has been over-rated, and that it is in any case discounted by serious disadvantages of the type of stove; but the test made by the Committee throws no light on these points, since the stove tested was not of the Continental regenerative class.

The experiments on the effect of variations in the composition of fire-clay "fuels" have led to some remarkable discoveries; and doubtless the lines of research which they suggest will be vigorously pursued by the makers of gas-fires. At present, it appears to be established from the investigations made that treatment of the "fuel," which provides a deposit of copper oxide in its outer layer, raises the radiant efficiency of the stove from 42·8 to 48·5 per cent.

Other treatments or variations in the composition of the "fuel" produced less substantial gains; but there can be no question that it is by the use of improved "fuels" that the next considerable advance in the efficiency of gas-fires will be achieved.

The work done by the Committee included also an investigation of the action of a condensing gas-stove. This stove contained an open gas-fire of fire-clay "fuel" heated by six bunsen flames; and the products of combustion were passed through eight vertical tubes to the shallow reservoir provided for the condensed water. It is satisfactory to learn that no trace of carbon monoxide was ever found in the products of combustion. The use of the stove caused a slight drying of the atmosphere of the room, though, of course, at the higher temperature due to the heating effect of the stove, the actual amount of moisture in the air was largely increased. The proportion of the sulphur in the gas consumed which was found as sulphur acids in the condensed water was determined in varying conditions: and it was found to vary inversely with the temperature of the room. At about 60° Fahr., the sulphur acids in the condensation product represented about 30 per cent. of the sulphur in the gas; so that 70 per cent. of the latter passed at that temperature into the air of the room. We are not sure, however, that this conclusion should be accepted as generally applicable, because the gas upon which the investigations were made contained only the abnormally low amount of 10 to 13 grains of sulphur per 100 cubic feet. Since the general abolition of sulphur restrictions, there is little gas supplied in this country containing less than 30 to 40 grains of sulphur per 100 cubic feet; and it is not unlikely that the proportion of sulphur acids extracted in a condensing-stove will vary to some extent with the degree of their concentration in the products of combustion. A similar comment may be made regarding the amount of iron dissolved from the inner surface of the "radiator" tubes, which was found to vary from 5·33 to 7·47 grains per 100 cubic feet of gas burnt. It would be interesting to know that this quantity would not have been sensibly greater had the amount of sulphur in the gas been more nearly normal.

Reviewing the whole of the research work now reported by the Committee, we have no hesitation in saying that it constitutes a most valuable accession to our knowledge of the principles underlying the more usual methods of heating by gas, and that all sections of the gas industry and the makers of gas-fires in particular, will reap very considerable benefit from it. Ultimately, the gas-consuming public will gain great advantages, as a result of the investigation. In a word, the small expenditure involved in the carrying out of these researches will be repaid a thousandfold to the commercial interests directly concerned. The Committee have been singularly fortunate in having secured the services of so diligent and able an investigator as Mr. E. W. Smith; and no small meed of praise and thanks should be accorded to him for his labours.

The Disposal of Profits.

It is easy to understand the demand of the Devonport Town Councillors that a portion of the profits realized by the municipal undertakings should be appropriated to the relief of the rates—all town councils have this experience. When rates are continually advancing, it is perhaps no more than natural that the men who are responsible should look for salvation to the business ventures which are so frequently heralded as sources of profit and contributors to the relief of the rates. Sometimes, as in the case at Devonport, they look in vain. Both the gas and the electricity businesses of the Corporation have had a good year; and in each case there is a substantial sum to place to the reserve fund. The Electricity Committee decided to give out of their balance a slight concession to consumers. Less fortunate, the Gas Committee found themselves unable to make an allowance to anybody—chiefly, it would seem, because of certain special charges which have taken from the reserve fund a rather larger amount than the net profit of the year. In these circumstances, neither the consumers nor the ratepayers get anything. We are not greatly impressed with the claims of the latter, as such, to consideration. In spite of the vicissitudes through which the undertaking has gone, no one can pretend that the ratepayers of Devonport have ever been in the least danger of incurring a loss over the gas-works such as would necessitate an appeal to the rates. If any concession was to be made, it should be to the consumers who have come forward in such numbers as to more than neutralize the loss of the supply of gas to the Dockyard. The Devonport Corporation have now owned the gas-works for nine or ten years; and so far there has been no reduction of price. The Town Clerk hinted at private reasons why contributions to rates or reductions of price are not easy to make in the case of municipal undertakings. These reasons must be substantial indeed if they are to outweigh what we think must be allowed to be the just claims of the gas consumers of Devonport.

GAS STOCK AND SHARE MARKET.

(For Stock and Share List, see p. 891.)

Business on the Stock Exchange last week grew quieter and quieter. Outside distractions in the world of sport (it was Ascot week) had something to do with this, but not enough to account for the extreme inanition—approaching somnolence at times—which benumbed the markets. Prices inevitably continued to give way; but before the close the tone brightened up, and promised some recovery. On the opening day, the indications were adverse. A failure, though of inconsiderable magnitude, was reported. The gilt-edged group were dull. But Consols stood still unchanged; and Railways were languid. The depressed Americans almost alone looked better. Tuesday was rather weak at first, but stiffened somewhat later on. On Wednesday, there was no strength anywhere, almost all departments drooping for lack of a little support. Business on Thursday was, if anything, even quieter still, and the dulness inseparable from inaction brooded over the markets. Consols shrank at the intrusion of the big Indian Railway loan—a cheap offer. On Friday, there was no abatement of the ruling inactivity, but there was a slight recovery in tone. Government issues were stronger; Consols had a small rise; Railways stiffened a little; and movements elsewhere were more cheerful. This tendency was maintained on Saturday. There was not much actual change for lack of motive power, but the better feeling was of happy augury. In the Money Market, a good steady demand found employment for a liberal supply; but discount rates ruled easier. Business in the Gas Market resumed its normal proportions; there being a good aggregate of transactions. Primitivas were even more conspicuous than ever, and there were more dealings in the preference shares last week than in Gaslight and Coke ordinary. There were few changes in quotation; and the general tendency was firm, though one or two minor issues were put down slightly. Transactions in Gaslight and Coke ordinary were at the same figures as the week before—103½ to 104½. In the secured issues, the maximum was dealt in at 88½ and 89¾, the preference at from 104½ to 105½, and the debenture at 82. South Metropolitan was also quite unchanged; all transactions being within the limits of 121 to 122. The debenture changed hands two or three times at 82. In Commercials, there was one deal in the 4 per cent. at 108, and one in the 3½ per cent. at 105. Among the Suburban and Provincial group, Alliance and Dublin marked 82⅜ and 83¼, Bournemouth "B" 16½, Brentford old 254, ditto new 188, Brighton original 215 and 216 (a rise of 1), British from 44 to 44½, Ilford "A" 145¾, ditto "B" 109, South Suburban debenture 122¼ special, Southampton 110½, and Wandsworth "B" from 140⅝ to 141. On the local Exchange, Liverpool "B" was done at 164½. In the Continental companies, Imperial marked 178 and 179, Union 95 and 97 (a fall of 1), European 24½ and 24¾, and ditto part-paid 18⅝. Among the undertakings of the remoter world, Monte Video changed hands at 12⅝ special, Primitiva at from 7¼ to 7⅜, ditto preference at from 5⅜ to 5 11/16 (a rise of ⅛), and ditto debenture at 98¾.

Visit of the Société Technique to Brussels.

As mentioned in the "Journal" some weeks ago, the members of the Société Technique du Gaz en France, who are now holding their congress in Paris, intend at its close to have an excursion to Brussels. They will leave Paris by midday train on Thursday, and reach the Belgian capital in the afternoon. In the evening there will be a reception by their colleagues of the Belgian Association. On Friday morning, the party will be conveyed to the Forest works of the Imperial Continental Gas Association, where, under the guidance of Mr. Salomons, they will have an opportunity of seeing the vertical retorts installed there, and of witnessing their discharge. In the afternoon, they will visit the Jette-St.-Pierre and Schaerbeek works of the St. Josse-ten-Noode Gas Company, who at the latter works have inclined retorts in operation. In the evening, they will inspect, under the conductorship of members of the Belgian Gas Association, the various systems of lighting at the Exhibition. Saturday will be devoted to the Exhibition—the morning being spent in the Belgian Section (particularly in the pavilions of the above-named Association); and the afternoon in the Lighting and Heating Divisions of the French Section. An invitation was extended to the President and Council of the Institution of Gas Engineers to join the party; and we understand that several of the members have accepted it.

OBITUARY.

CHARLES HANSON GREVILLE WILLIAMS.

We regret to record the death on the 15th inst., at his residence, Bay Cottage, Smallfield, near Horley, of Mr. Charles Hanson Greville Williams, F.R.S., who for many years held the position of Chemist to the Gaslight and Coke Company, and whose name, some years ago, was frequently before the members of the gas industry from his contributions to the literature bearing upon chemical questions connected with it, most of which appeared in our columns. His contributions dealt with the following subjects: "Determination of Boiling-Points in Tar Distillation" and "Production of Liquid Hydrocarbons from Waste Gases" (1879); "Determination of Sulphur in Coal" (1882, in conjunction with Mr. Hamilton Dove); "The Action of Some Heated Substances on the Organic Sulphides in Coal Gas" and "The Antiseptic Alkaloids contained in Creosote Oils" (1883); "The Referees' Ammonia Test" (1884); "The Occlusion of Hydrogen by Zinc Dust and the Meteoric Iron of Lenarto" and "Source of the Hydrogen Occluded by Zinc Dust" (1885). Mr. Greville Williams did not confine himself to the investigation of subjects such as those mentioned; for in the summer of 1890 we described briefly a method he had devised for producing artificial emeralds from the refuse of gas-retorts. In the domain of gas-works chemistry, he gave special attention to the subject of the distillation of tar. As some of our readers may remember, he was the writer of the article on "Tar and Tar Products" in "King's Treatise on Coal Gas;" and at the meeting of the British Association of Gas Managers in London in 1880, he delivered a lecture on "The Past, Present, and Future of Coal Tar." Two years later, he contributed to the Gas Institute a paper on "The Determination of the Specific Gravity of Gas." He had of late lived somewhat in retirement; and was consequently unknown, except by repute, to the rising generation of gas engineers and managers. He was a Fellow of the Royal Society; and apart from his scientific attainments, he possessed considerable knowledge of Egyptology, the study of which was the recreation of the later period of his life. He was in his 81st year.

Last Wednesday morning, the Stretford Gas Company were deprived of the services of an old employee by the rather sudden death of Mr. Benjamin Haynes, who had been with them for nearly fifty years, for about the last thirty of which he had filled the position of Secretary. In his long connection with the Company, he had seen the district develop from a comparatively quiet village to the important industrial centre it is to-day, with its gas consumption of 327 million cubic feet compared with 50 millions half-a-century ago. Deceased was in his 69th year.

The death took place, on Monday of last week, of Mr. Charles Crowther Smith, who for about thirty years occupied the position of Secretary of the Southampton Gas Company. Some years ago, however, he retired on superannuation, and was elected to a seat on the Board. Deceased, who was eighty years of age, was one of the best known public men in Southampton, to which town he went in 1847, on receiving an appointment at the local County Court, which he held for thirteen years. He was appointed Clerk to the Southampton Board of Guardians in 1860, and continued in the office till 1896, when he retired on a superannuation allowance. Five years after his appointment as Clerk to the Guardians, he became Secretary to the Gas Company. As Clerk to the Guardians, Mr. Crowther Smith became an authority upon rating questions, and was personally concerned in at least two important cases. He individually conducted and won an action against the New Forest Guardians (which went right through the Courts to the Court of Appeal), against the payment of poor-rates on unoccupied land; while in another case he appealed against a rate made by the Corporation of Southampton, and the rate was quashed. He twice gave evidence before Royal Commissions—those on Poor Law Removals and Local Taxation; and in recent times played an important part in the local disputes which resulted finally in the inclusion of the parishes of Shirley and Portswood in the area of the Borough of Southampton for municipal and poor law purposes. The gas world similarly, it is pointed out in an appreciative notice which appears in the columns of a local paper, looked upon Mr. Smith as an authority upon various phases of the lighting industry; and he played a foremost part in making the arrangements for the annual conference of the Gas Institute at Southampton in 1902, when Mr. S. W. Durkin, the Manager of the Southampton Gas Company, presided. The funeral was on Thursday afternoon in Southampton Cemetery; there being a large attendance, which included Captain A. J. Corse-Scott, J.P., the Chairman of the Gas Company, and many of the Directors and officials. One of the floral tributes was inscribed: "With deep regret, from the officers and staff of the Southampton Gaslight and Coke Company."

The marriage is announced, as having taken place at Cork on the 11th inst., of Mr. Frederick William Taylor (Secretary and Manager of the Harpenden District Gas Company), son of Mr. Frank C. Taylor, of Shanklin, to Kathleen Sheelah Mary, youngest daughter of the late Mr. George R. Pemberton, of Dublin, and granddaughter of the late Sir Benjamin J. Pemberton.

GAS ENGINEERING AND SUPPLY EXAMINATIONS.

Some of the Successful Students.

We are, unfortunately, unable this year (as has been our custom) to publish the complete pass list of the City and Guilds of London Institute Examinations in "Gas Engineering" and "Gas Supply," owing to an intimation from Sir Philip Magnus, the Superintendent of the Department of Technology, that, "owing to the extreme pressure of work at this office, and for other reasons, it has been decided that the pass lists shall not be supplied to the Press." Without stating what the "other reasons" are, Sir Philip Magnus hopes we shall "understand that it has been found impossible to arrive at any other conclusion." However this may be, perhaps the successful candidates themselves will feel disappointed at the innovation; and therefore it is that we offer this explanation of the reason for the omission of the complete list. But even on this occasion it is possible to do something in the matter; for, by the courtesy of Mr. R. H. Collins, we are able to publish a list of the Polytechnic students who passed this year's examinations.

REGENT STREET POLYTECHNIC.

City and Guilds Examinations, 1910.

GAS ENGINEERING.

Honours, First Class Pass.

Ashmole, Gordon
Barclay, Warren
Broadberry, Leonard
Cross, Douglas C.
Mann, Harold C.
Webb, Francis S.
Winslow, George
Willsmer, Norrie

Honours, Second Class Pass.

Waterfield, Edwin W.
Wellard, Leonard

Ordinary, First Class Pass.

Allen, Henry J.
Brown, William
Carpenter, George E.
Croxford, Leslie J.
Donaldson, John H.
England, Albert A.
Hilson, John G.
Hole, George
Jeffreys, J. S.
Page, James L.
Partridge, Henry
Priest, Francis R.
Winslow, Alfred D.

Ordinary, Second Class Pass.

Alford, Arthur N.
Caudwell, Frank
Clark, William H.
Howard, William C.
Larkin, Leslie
Parsons, Edward
Prentis, Arthur E.
Snook, Walter

GAS SUPPLY.

Honours, First Class Pass.

Cardwell, Frank
Cross, Douglas C.
Rosevear, Charles E.
Winslow, George

Ordinary, First Class Pass.

Webb, Francis S.

Ordinary, Second Class Pass.

Sumner, Horace R.

Coalite.

In a recent issue, the "Journal of the Society of Arts" wrote Two or three years ago a good deal was heard about a new process of manufacture which produced what was called "coalite." A Company was formed with a capital of £2,000,000 to work the process; and prospectus estimates showed an annual profit of over £500,000. The Company has now been in existence for nearly three years. It has spent about £600,000; and it is in immediate want of more capital, which it is obtaining by means of an issue of £300,000 in 5 per cent. debenture bonds—part of an authorized issue of £500,000. Meantime, far from having earned the promised half-million sterling in the way of annual net profits, it has paid no dividend; and the question for the public is whether the new capital asked for is likely to enable it to do so. The Directors are very confident that it will. But it is not reassuring to know that three of the original Directors, including Sir Arthur Cory-Wright, have retired from the Board; and that some months ago another patent for the manufacture of coalite was granted, which at least shows that the patents held by the Coalite Company do not prevent other processes making coalite being put upon the market. Again, the Company has been unfortunate with its plants. It is said by those who should know, that at the present time the Company has not a plant at any one of its stations which can produce good coalite at a profit; and at Hythe the Company is said to have now reverted to the high-temperature retorts which were working before the coalite process was adopted, and gas and tar are being produced by the ordinary gas-works methods. It is said, too, that at Wednesfield two gas-engines of 300-H.P. each were erected more than a year ago for the manufacture of ferro-silicous and chlorate of soda; but neither of these products has been made, and the expensive plant remains idle. It may be that success will attend the future efforts of the Company. Coalite is itself a good thing; and its present apparent failure as a commercial product may be due to preventable causes. But on the face of it, it seems one of those processes which look very inviting in the experimental stage, but fail to justify themselves from the commercial stand point.

THE INSTITUTION OF GAS ENGINEERS.

PROCEEDINGS AT THE EIGHTH ANNUAL GENERAL MEETING,

HELD AT THE

INSTITUTION OF MECHANICAL ENGINEERS, STOREY'S GATE, LONDON,

JUNE 14, 15, and 16, 1910.

MR. JAMES W. HELPS, OF CROYDON, IN THE CHAIR.

REVIEW OF PROCEEDINGS.

(For Full Report see page 791.)

"TIME rolls its ceaseless course." Once more we found ourselves, on Tuesday morning, at the steps of the Institution of Mechanical Engineers, surrounded by gas engineering friends from all parts of the country, with genial greeting on every lip, and with further expression in the heartiness of the grip of the hand. In the vestibule, the same; and on to those with whom one came in contact in the well-known lecture-hall. The brightness of the morning was reflected all around. The benches in the lecture-hall were filling well before the appointed time for the beginning of the proceedings. As one looked about him and in the distance, the eye alighted on representatives of the gas industry from distant climes. There was Mr. J. C. Watson, relieved for the time being of his official work in Calcutta, and Mr. P. Holmes Hunt, from his duties in Australia. Mr. Chas. H. Nettleton and Mr. Burghi were present from America; and there may have been still more who are daily engaged in the work of gas supply in other countries. The front row of the gallery was filled with ladies (among them Mrs. Helps and the elder daughter of the President); and they were interested spectators of the animated scene below. The clock pointed to 10.30. The President (Mr. James W. Helps) appeared, accompanied by the Hon. Secretary (Mr. S. Y. Shoubridge), a long line of councillors, including the elected of the District Associations, and the Secretary (Mr. Walter T. Dunn). When the President took his seat, it was seen that the University of Leeds was represented on his right-hand side by Professor Arthur Smithells; and on his left were the Vice-Presidents of the Institution, Mr. Alex. Wilson and Mr. R. G. Shadbolt.

The room was well filled. Intuition gave the premonition. There was silence. "The memory of the great loss we have sustained would not allow us to open our meeting without referring to it." Those were the President's introductory words. Brief though the sentences were that followed, they were to the point; and by noiseless rising from their seats, the members endorsed a resolution, which is to be engrossed and forwarded to the Home Secretary, expressing the profound sorrow of those present, and recognizing the practical interest of our late Sovereign in the progress of engineering science, and particularly in those branches relating to the industry represented by the Institution. The solemn duty performed, formal business succeeded. Minutes were read, and the report of the Council adopted, without comment. Then, with suitable recognition individually of their contributions to last year's proceedings, the President called to the platform singly Mr. J. Ferguson Bell, to receive the London Gold Medal; Dr. Rudolph Lessing, to take possession of the Institution Silver Medal; and Mr. Robert Watson, of the Institution Bronze Medal. The three recipients obtained and merited the applause of those present. Hearty welcome was next accorded by the President to the several visitors present; and then there was a settling down to listen to a Presidential deliverance that, in its effect, it is hoped, will be a memorable one in the annals of the Institution, and mark the preliminary stage in a career of expanded usefulness on the part of the central organization.

Greater Co-Operative Work.

At first the President's voice hardly penetrated to the remote portions of the hall; but it gathered strength as he proceeded. Again were expressed the feelings of sorrow of all who are loyal to country and constitution at the passing of King Edward the Peacemaker, for so in history he will be known. The more immediate loss to the gas profession and the industry in the death of Mr. Alfred Colson received words of regret and sympathy and of appreciation of a life well spent. Concurrence, on these occasions, expressed by silence where a number of men are gathered together is always impressive. It was so at this point. Then we passed on to matters from which, there is hope, there will be much material result. The addresses of a long line of predecessors in the chair have been good in material; but this one had a definite object appealing to the whole industry, and designed for the whole industry's good. The address was published last week, and comment is made upon its principal theme elsewhere in this issue. It first refers to the great changes that have occurred in the gas industry, during the progress of which changes, through the expansion of the uses of gas, there is no depreciation of, but much gain in, prosperity. The several fresh needs call for the application of changes in the conduct of the industry's business. The methods and practices of the shopkeeper have to be adopted—and more. Officers and workmen in the distribution department have to be specially trained for their work, and the qualifications of the gas-fitter have to be diverse. Then there is discussed the question of the quality of gas the consumer requires to-day; and there was general approval—not one voice was heard in dissent—when the President said: "I look forward to the time when Parliament will recognize the fact that, for all purposes to which gas is at present applied, its illuminating power is a factor of the most trivial importance, and will, in consequence, eventually decide to abolish the illuminating power standard in favour of one indicative of its heating value." The President has found—especially with vertical retorts and horizontal retorts fully charged—that it is possible to decrease the illuminating power of gas while actually increasing its calorific value. And regarding the allegation of opponents that the introduction of the No. 2 test-burner will result in consumers having to use a larger quantity of gas in order to get the results previously obtained, figures supplied to him by companies who have been using the burner for some time proves the contrary. While on the question of quality, an instructive account is incorporated of work done at Croydon (suggestion in regard to which is freely credited to Dr. H. G. Colman) that has given relief from the nuisance of naphthalene deposits.

The great feature of the address lay in the end. The time has come, in both the technical and the commercial work of the industry, when it is necessary that there should be more co-operation; and for the work to be done, and actually waiting attention, there must be given both the moral and the pecuniary support of the whole of the gas undertakings of the country. To instance one commercial question only—that of national advertising. The activity of the electrical industry must be met with activity that is commensurate in scope, and that will appeal to the public. It is imperative, and an indispensable condition, that the interest of Boards of Directors and Committees should be secured to gain the end. But as present constituted, and in its character of a purely technical organization, the President does not consider the Institution equal to the work or possessing sufficient commanding power to attain the

necessary support. Prominent though he personally was in bringing about the amalgamation of the old Institute and Institution, he now confesses that the end that he and others had in view has not been accomplished in the matter of full representation. But there is really no ground for regrets. The years since have produced such a unity in the professional organizations of the industry, that we see in this an excellent preparation of the way to the still more substantial representation of the industry. The President favours the continued separate existence of the Society of British Gas Industries, as he sees in it the capacity for excellent work on lines essentially appertaining to its members, and a great usefulness in co-operative work with the central organization of the gas-supply industry. But the necessities of the industry demand a central organization with a constitution embracing the heads of the secretarial and distribution departments. To gain extended support for the work lying around, greater interest of the gas undertakings has to be attached. The President suggests—but it is only a suggestion—that two courses are open to this end—either to alter the present Articles, so as to allow of the admission of the officials to whom he has referred, or to change the name of the body to the "Gas Institute," and to divide the work up into sections, as is done by the British Association. Personally, he favours the latter, as he believes it would result in the formation of a powerful and numerically strong body, thoroughly representative of the various interests concerned, and therefore particularly well calculated to secure the co-operation of the various officials and the consequent confidence and financial support of the undertakings they serve. Among concluding suggestions were these, that the matter should be referred to either the Council, or a specially appointed Sub-Committee, for consideration and report; and further that representatives of Boards of Directors and Committeemen should be brought together to consider the subject. Such a meeting of Directors and Committeemen was again suggested by Mr. S. Y. Shoubridge during the discussion on national advertising at the meeting convened by the Commercial Sections in the afternoon. What has to be done is to get face to face with them, explain the position, and solicit and endeavour to secure their adhesion to a scheme of larger co-operation.

A Resolution.

There was much applause at the close of the well-reasoned address, which was continued when it was seen that Mr. Corbet Woodall was on his feet to express the sentiments of the members as to the character of the address, and of its worthiness to a place in their thoughts and in the Institution's "Transactions." Mr. Woodall did not share in any inference that might be drawn from the address that the men who carried on the work of the industry had not proved equal to the changes of the past score years. The address itself is a refutation of any such deduction. There seemed to be the trace of an indictment in Mr. Woodall's words as to the Institution not having done sufficient to secure the confidence of gas undertakings when he said: "I feel quite sure that if the Institution is able to show by the work it does that it is worthy of carrying on the widely extended usefulness to which the President has referred, there will be no considerable difficulty about finding funds." He quoted the German and French Gas Associations in support. The conditions are quite different there. The Institution cannot —they have tried again and again—obtain sufficient support as they are at present constituted. Mr. Woodall has not had to canvass for money for the industry's purposes; and his influence on the Boards with which he is associated goes a long way to a ready acquiescence in his proposals regarding subscriptions. That experience cannot be commonly applied. However he is with Mr. Helps; and he hopes that the propositions of the address will be thoroughly weighed. To that end, combined with the vote of thanks, he proposed a resolution authorizing the Council to appoint a Committee to consider the suggestions, and to report. A hearty seconder was Mr. John West, who tersely stated the position, when he said that a great deal had been done by the Institution, but there remains a very great deal that might be done by a central organization. Mr. E. A. Harman seemed to think the resolution a little premature. But there is nothing committal about it beyond inquiry; and so it was passed without a dissentient. In his acknowledgment, the President said the whole object behind his suggestions was to get the support and the means to carry on thoroughly the work of a central organization; and support and means should be contributed by every undertaking. There the matter is left for the present—to bear, it is hoped, good fruit.

Buying Illumination for Street Purposes.

Of the appropriateness for a meeting of the Institution of the paper by Mr. Jacques Abady (which was the first to be presented and discussed) on the subject of "Public Lighting from the Municipal Point of View," there can be no question; and, from the critical standpoint, no one could be better qualified to examine the subject of the relationship between the suppliers of public lighting and the public lighting authority. A barrister, there is the question of lighting contracts. A photometrician, there is the matter of lighting efficiency. A municipal councillor, there are the aspects of the matter from the local authorities' point of view. A manufacturer of gas and electricity testing appliances, and so in close touch with the suppliers of those commodities, there are the considerations affecting the question from the point of view of the latter. And further interest is added to his appearance as the author of this paper, in that he is the Chairman of the Committee of the Westminster City Council upon whose recommendation a contract has been entered into that has arrested the attention of the whole lighting world. With the manner in which Mr. Abady deals with the subject, not even the most captious electrical critic can fairly find fault; and it has been his aim, throughout this business, to keep himself aloof from even the semblance of partizanship.

To satisfy all the interests involved in public lighting is a difficult matter; and the difficulty has not been lessened by competition. But the author submits that, given a light of a certain value, distributed in a certain manner, it does not seem of importance to the public whether that light is produced by gas or by electricity—the sole consideration should be the question of relative cost. There will be some disposition to dispute this. He lays it down as an axiom that the terms of any contract should establish a mutuality or community of interest. But he finds that the general forms of public lighting contracts are, in some way or other, defective, and disadvantageous to one or other or both the parties, and exercise an adverse influence in some one or more directions. He makes out an excellent case. The ordinary forms of contract are: (1) For the supply of energy, with maintenance; and (2) For the supply of energy only—maintenance being undertaken by a contractor acting for the municipality, or by the municipal lighting department itself. Under the first form of contract, there would be considerable difficulty, in the case of a careless gas or electricity management, in ensuring that the condition of the public lights should always be satisfactory. Under it, too, there is a stop or no encouragement to progress. Under the second form of contract, a gas company's interests may be seriously jeopardized by an indifferent maintenance contractor, or an indifferent public lighting department. The defects of such contracts fall thick and fast in the paper. There is a good deal of a commendatory nature in it as to the Calcutta public lighting contract, under the conditions applying to Calcutta. In close conjunction is found this deliberate expression of opinion: "It seems to me that a direction in which future improvements in the efficiency of gas lighting are to be found will be in the reduction of the quality of the gas and an increase in the pressure at which it is supplied; so that, by reducing on the one hand the amount of air theoretically required for perfect combustion, and increasing on the other hand the mechanical means by which that theoretical amount of air is obtained in practice, we shall be enabled to burn the right quality of gas under conditions of absolute maximum efficiency."

The greatest interest in the paper concentrates about the new form of contract entered into by the Westminster City Council with the Gaslight and Coke Company for the supply of light, payment to be made for so much light irrespective of the energy required to produce it, and irrespective of consumption, quality, and pressure. The salient clauses of the contract are appended to the paper; and they will be diligently studied. There is a heavy penalty attached to deficiency of illuminating power; and the details of the testing clause are given. A portable photometer is to be employed; and one set of tests is to be made at an angle of 20° to the horizontal, and a second set at 50°. The chief terms are subject to various conditions. The tedious mean hemispherical candle-power test would have been impracticable for this particular purpose; and it may be taken that, in the majority of cases, the mean of the light given at 20° and 50°

practically coincides with the mean hemispherical intensity, and therefore fairly represents the value as candle power. What this form of contract has reduced the whole question to, is one of price against price for the supply of the same light; and the lowest tenderer succeeds. If, under these circumstances, the photometrical instrument and method of testing are the subject of agreement, then the gas or the electricity suppliers know precisely to what they have to work—provision, of course, being made for no tests during rain, mist, or fog. These are safeguards. It transpires that the Gaslight and Coke Company have already had five years' experience in the City of Westminster of a contract on a photometer basis; so that they know what they are about. In the author's opinion, buying and selling street illumination by light value is the most direct, simple, and generally advantageous course. The final part of the paper discusses many pertinent points bearing upon the photometrical aspect of the question; and statistics and curves are given in the supplement. The paper, novel and informative in many ways, is one that no one connected with public lighting, technically or commercially, can afford to be without, and to thoroughly digest; for nothing like it has ever been attempted, or, if attempted, has been published.

Mr. Abady has the faculty, which few possess, but many envy, for verbal condensation of an extensive subject. He did not read his paper, but gave a *précis* that put the members in possession of points and argument. Among his asides, he spoke highly of the distribution power of the vertical form of burner for street illumination; but inverted burners, on the other hand, save a lot in mantles and consequently in trouble, and for street illumination they should be fitted with proper reflectors. Another point is one of nomenclature. He suggests the coining of a term which includes both the pressure at which the gas is delivered and the volume supplied. A better idea in the designation of the value of what is being sold and what is being bought is required than mere "cubic feet." For instance, 3 cubic feet at 12 inches pressure is not the same thing as 3 cubic feet at 60 inches pressure. He placed much emphasis on his preference for a lower grade gas at high pressure than for a rich gas at low pressure.

Sundry Views.

Many good things were said in the discussion about the paper. Its extreme value was recognized; and the tables and other matters, it was agreed, would be very useful in getting out a lighting scheme. Mr. Abady must have been happy with so many panegyrics flying from different quarters of the room. The speakers were: Mr. C. E. Botley, Mr. F. W. Goodenough, Mr. George Helps, Mr. C. E. Jones, Mr. R. G. Shadbolt, Mr. H. E. Copp, Mr. Thomas Canning, and Alderman Griffiths (Southport). So far as there were expressions of opinion, it was agreed that the principle enunciated, of contracts being founded on an illumination basis, is the correct one. It was regarded as the most scientific; and it does leave everything under the control of the gas suppliers. Hard knocks were applied to municipal owners of electricity undertakings, who will not treat public lighting on its merits. The principles put forward by Mr. Abady are shunned by them, though, of course, if they can supply (without financial loss, or direct or indirect injury to ratepayers or electricity consumers) a better light for less cost than can be obtained by gas, they are justified in doing so. Mr. Canning questions whether it is not illegal for such municipalities to enter into contracts with the electricity departments without submitting the matter to tender. As to a photometrical contract being any block to progress in the adoption of means of securing higher illumination efficiency, it is thought that it would be rather the reverse, as during the remainder of a contract (if the remainder were sufficiently long) it would be to the benefit of the company to make the change, and to the municipality on a new contract being entered into. A wise gas company, with an eye to future favours, Mr. Abady thinks, would offer to share the savings immediately with the municipality. More than one speaker regarded high-power lights as being an uneconomical form of lighting in relation to illuminating efficiency, preferring small units placed fairly close together. But there was agreement as to the advertising value of the former. As to the advertising usefulness of the public lighting to gas suppliers, this is rather difficult to estimate; but Mr. Shadbolt points out that public lighting may be done at such a low figure as to be a tax on the ordinary consumer.

On the point as to the relative efficiency of the vertical and the inverted types of burner for street lighting, the high efficiency, reduced consumption, low mantle costs, and good distribution (when fitted with proper reflectors) were pointed to as being unanswerable advantages on the side of the latter. The submission that, on the illumination basis of contract, cost is the only arbiter, Mr. Canning seemed inclined to dispute, as there is the practical question of the relative diffusiveness of electric and incandescent gas lamps. He finds this difference in his tests; and Mr. Abady gives the only explanation of which he is aware, that the source of illumination in electric lamps is very small and of high intrinsic intensity, whereas the source of illumination with incandescent mantles is much larger. Concerning distribution pressures, all who referred to the subject see advantage in raising them.

Publicity for the Gas Industry.

In the afternoon, there was a joint meeting of the Commercial Sections, to which members of the Institution who are not associated with the Sections were invited. The chief topic of discussion was the question of national advertising, and the important one in association with it of ways and means. The proceedings were in the nature of a preliminary conference; but it may be stated that a report proposing the formation of a Gas Publicity Committee, to be composed of members of the Commercial Sections and co-opted members, was adopted—the resolution including an instruction for a conference with the Council of the Institution. More is to be heard of the matter when the proposition has been brought to more definite shape. The question of financing is an important one; and it seems to hang very much on the bringing into closer contact with a central organization of those who can provide the money.

A Generous Offer.

On the last day of the meeting of the Institution, it was announced by the President that the Directors of the Tottenham and Edmonton Gas Company had resolved, in connection with the joint advertising scheme, to undertake to contribute to a fund for the purpose at the rate of 2s. 6d. per million cubic feet of gas sold, provided fifty other gas undertakings will enter into the same arrangement. The Board of the Company are prepared to guarantee this for three years. This paves the way for starting a good scheme.

Benevolent Fund Work and Apathy.

The first item on the *agenda* for Wednesday morning is the one most neglected by members of the Institution. Comparatively few of the members were present to hear of the requirements of this fund, and of its potentiality for good among the dependents on the benevolence of the industry. The amount of the subscriptions from members of the Institution bears a very poor relation to its numerical strength. The President has made an appeal by letter for further assistance. The District Associations are responding; but beyond them there is not any great amount of encouragement. A further appeal was now made by him; and this was supported by Mr. J. Ferguson Bell, Mr. Kendrick, and Mr. George Helps, the last-named of whom offered that he would make himself responsible for collecting £10 from among his friends if so desired. Why not appoint collectors in this way from among the members? There are many probably who would like to subscribe through a private individual—anonymously if not by name. It was mentioned by the President that, though the Benevolent Fund Committee do not canvass for outside subscriptions, they are quite prepared to accept offers of subscriptions from anyone not directly represented by membership of the Institution. There are many readers of the "JOURNAL" who might like to take note of this.

Gas-Heating Research.

The report of the Gas-Heating Research Committee was then introduced. It is a voluminous document, and indicates that Mr. E. W. Smith, the Research Chemist, has been diligent and eager over his work at the Leeds University. The main directions in which he has been occupied during the year are in making experiments upon the relation of gas consumption to radiation efficiency; upon the relation of the composition of fuels to radiation efficiency; upon the radiating power of naked flames; and upon condensing-stoves,

It seems from the early part of the report that we have to discount somewhat the radiant heat tests quoted last year. Modification has since been made in the mechanical arrangement of the method for determining radiant heat, as it was found too cumbersome. The result is rather better radiant heat readings. Quite a large number of different makers' fires have been up for testing in connection with the inquiry as to the relation of gas consumption to radiation efficiency. In testing, they were varied until the greatest efficiency was attained. In one or two instances, it was found that the stoves, after being adjusted to suit the conditions under which they were tested, gave 4 or 5 per cent. better efficiency than when used as they were forwarded from the makers. The expectation of the makers that their fires will be adjusted when fixed, is not always the subject of realization, though they at their works cannot adjust to the local conditions under which the fires are to be used. So much the worse for the makers' reputations. To them, a careful study of the report will supply many hints.

There are certain conditions that will give the highest radiation efficiency within the range of present knowledge; but these conditions do not appear to be compacted in the whole into any one maker's fire. There is the necessity for having fuel that will fit the flames, or flames that will fit the fuel. The fuel must stand well over the flames; otherwise there will be reduced radiation efficiency. The fuel should be regular in length, and should not be irregular on the inside. Flames should be even in length; and good and convenient gas and air adjustment should be provided. These are matters that receive variable attention in the stoves submitted to test. Then, again, there is great divergence in practice respecting the provision at the top of the fires to capture as much of the waste heat as possible without diverting it down the back of the stove. Some fires are so arranged and constructed as to effect this, and so to obviate a high flue loss. This is commended. Attention is urged to the firebrick back—on account of its radiating power, its usefulness in keeping fuel in a vertical position, and so forth. The claim as to the radiating superiority of the iron-fret stove gets a little knock in this report—determinations showing that, although the iron-fret stove is equal to the fire-clay type, yet it is not better; and the advantages of the latter, from the points of view of cleanliness and appearance, make it much to be desired. There is, too, rather more chance on first lighting of carbon monoxide being liberated from the iron-fret stove. An incandescent mantle stove is referred to; but being in the experimental stage, not much is said about it yet. But generally, in this section of the report, it is found that the radiant heat efficiencies of the various stoves tested range from 37 to 43 per cent. Change in the testing apparatus and better attention to testing details may account for the increase upon the figures in the first report; but perhaps the makers will claim that their own work has not been altogether without effect. Mr. Smith puts it forward as probable that the highest radiant efficiency attainable with the present type of open fire where the air of the room has free access to the front of the hot fuel, will be little more than 50 per cent. Although this may be so, there is no reason why the heat that has been allowed to pass up the flue should not be utilized more than has been the case hitherto.

Of course, the point of most importance in the study of the principles underlying the working of a gas-fire of the radiating type is the convenient and economical generation of the requisite amount of heat, and the transference of the heat of combustion to the radiating material employed. In this connection, the amount of heat the flame itself radiates is worthy of consideration. Mr. Smith's tests generally confirm the findings of Professor Callendar, that variations in the size or volume of flame, vary considerably the radiation efficiency, as does also the amount of the aëration of the flame—the less the aëration, the greater the efficiency. Closing his information regarding this particular line of research, Mr. Smith remarks that, when the flames are surrounded with fire-clay fuel, the heat is being conserved to the flame, and, in all likelihood, the flames themselves in a gas-fire are radiating more than without the fire-clay fuels. It is probably safe to suppose that these flames radiate at least 16 per cent. of their total energy. References to experiments on the radiation from luminous flames follow; and then there is a discussion as to the extent that radiating efficiency of an open gas-fire is affected by variations in gas consumption. There is an example of a fire stated by the maker to be for a consumption of about 27 cubic feet per hour. But in the experiments the maximum radiation was reached when the gas consumption was 31 cubic feet per hour; and by increasing or decreasing this rate of consumption, the radiant efficiency is decreased. Trials with the duplex form of burner show that leaving three burners (out of seven) full on, gives a better radiating efficiency than turning down the whole seven.

Dealing with the subject of fuels, it is suggested that there are two main courses of investigation open to those desiring to increase the radiant efficiency of a stove by modifications in the composition of the fuels. In one, determination might be made of the effect of colour on the amount of heat radiated from the fuel; and, in the other, the effect of varying constituents in the composition of the fuels bringing about a selective radiation for heat in somewhat the same way as the thoria-ceria mixture causes selective radiation for light. Mr. Smith's experiments with specified clay have carried him to the point where he is led to suppose that (for this clay) there is a maximum porosity which is useful as an aid to radiation. The value of the degree of porosity in the fire-clay lies in the fact that the porous clay requires less heat to get it to the same temperature as the less porous clay. The porous fuel also has a rough surface which appears to take up the heat from the flames better than a smooth surface. In regard to the question of half fuels, the experiments result in the finding that, without special adaptation, an equal efficiency may be obtained without the front portion of the fuel. Succeeding is much information on experiments regarding fuels of varying composition; the figures indicating that the radiant efficiency of a fire can be increased to an appreciable extent by such means.

The last part of the report deals with condensing-stoves; the conclusions being summarized as follows: The amount of the sulphur acids condensed in the type of "radiator" under examination varies with the temperature of the room. At normal temperatures (60° Fahr.), this amounts to about 30 per cent.; leaving 70 per cent. to pass into the atmosphere. There is a slight drying of the atmosphere, though the actual amount of water vapour present is largely increased. No trace of carbon monoxide was ever found in the products of combustion. The room was well ventilated; and under these conditions no ill-effects were experienced by those present, except during the first three experiments when the smallest amount of ventilation was maintained. The amount of iron dissolved from the inner surface of the "radiator" tubes varied from 7·47 to 5·33 grains per 100 cubic feet of gas burnt.

Trials with Non-Illuminating Gas.

The contents of the report were supplemented by Mr. Smith stating that a method, is now being devised for estimating the radiant heat in a much shorter time, and in a simpler way, than at present. The existing method is accurate, but it takes a long time, and an experienced individual, to deal with it. By the new method, only about ten minutes will be required to obtain a test. Arrangements are also being made to test gas-fires with producer gas, Mond gas, and water gas. This investigation will be rather important in connection with the question of calorific and illuminating values. Mr. Smith is of opinion that the efficiency of gas-fires will be quite maintained by the use of water gas. The reason is that a great cooling effect results by passing through the fuel the quantity of air required for the combustion of the ordinary town gas; with the poorer gases, the amount of air needed will be less. The air, gas, and flame can be better adjusted to the fuel.

The Makers' and Other Views.

A number of the members of the Gas-Stove Section of the Society of British Gas Industries were present; and they added much of practical value to the discussion. The speakers were Mr. Samuel Glover, Mr. H. J. Yates, Mr. W. H. Y. Webber, Mr. H. M. Thornton, Mr. W. J. Liberty, Mr. A. P. Main, Mr. J. H. Brearley, Mr. H. Kendrick, Mr. F. W. Goodenough, and Professor Smithells (Chairman of the Gas-Heating Research Committee). Mr. Wilson and Mr. Davis had intended to speak; but time would not allow. It will be gathered from this list of speakers that the discussion was of considerable length. The praise for the work done by Mr. Smith was universal; and those who could more especially appreciate the amount and value of the work done—the gas-stove makers—were the heartiest in their encomiums. In this connection, Mr. A. P. Main made confession that the enthusiasm of the gas-stove makers

sometimes carries them beyond the limits of truth; and he thinks these independent impartial scientific investigations will act as a continuous check on the manufacturers.

Glancing at some of the subjects raised rather than taking the order of speakers, gratification was expressed by Mr. Thornton on behalf of the makers that the instruments used in testing gas-fires, through the work at Leeds, are now so accurate as to form veritable standards. There was much said on the subject of "fuels." Mr. Glover seems to have an objection to the term "fuel" as applied to the incandescing material of gas-fires; but the term has been adopted advisedly in the report in order to escape the charge of pedantry. "Radiants" is an appellation suggested by Mr. Yates; but it would not be at all a popular one. The composition and conformation of the fuel are directions in which the makers have worked assiduously; and there is regret that they have not yet been altogether successful. Mr. Yates points out that cost is a commercial factor of which sight must not be lost. Mr. Main hopes the inquiry will continue into these matters at Leeds. The proper length of the fuel is also still a disputed question. The report suggests that the longer fuel gives greater radiating efficiency, though full incandescence does not continue to the top. Mr. Thornton, however, is dubious as to whether appearance should be sacrificed to a little increase in radiant efficiency. Better results are obtained by Mr. Kendrick by displacing the longer fuel, and using short fuel with cross pieces on the top. The makers are all pleased to find that Mr. Smith has realized higher radiation values in the past year than in the previous one; and it was satisfactory to hear from both Mr. Yates and Mr. Thornton that higher values even than those quoted in the report are now being realized by them. Upon the wide fire, Mr. Yates places his faith in respect of the improvement of radiant efficiency. A cognate point, in reference to efficiency, is that the flame must fit the fuel, upon which Mr. Thornton directs attention to the fact that if there is a drop in pressure there is a drop in efficiency, as the fire is adjusted at a certain pressure, and a pressure decline must alter the shape of the flame. Mr. Yates laid it down as axiomatic that, provided the envelope of the flame is kept in contact with the fuel, the greater the aëration the greater the radiation. Speaking of the adjustment of gas-fires, it was properly insisted that this must be done *in situ* to suit local conditions; and herein is, as Mr. Goodenough remarked, an argument for the trained gas-fitter.

A Question of Pressures.

There is curiosity on the part of Mr. Webber as to the effect on radiating efficiency of increasing the pressure of the gas; and this he suggests as a line of work for the research chemist. The higher the pressure (he was speaking of the pressure behind the nipple) the more efficient the burner, is a safe generalization. The point was one of the interesting features of the discussion; and it disclosed a variation of views. It was fancied by Mr. Liberty that Mr. Webber had overlooked the effect of higher pressures on the gas-fire user; but Mr. Liberty had apparently himself overlooked the fact that pressures are adjustable at the nipple, as mentioned by Mr. Kendrick. Admitting that it is an interesting problem, and that wonderful results can be obtained with high pressures in gas-fires, Mr. Main pointed out that the discomfort occasioned by the noise makes the use of higher pressures at present out of the question. Rather sceptical is Mr. Brearley as to going to higher pressures than 2 inches for gas-fires. Commenting on the matter, Mr. Smith said the effect of high pressures was to take in more air, and to get concentration of heat at a given point. If this is done, there may be too great a concentration. He maintains that there is no necessity to have higher pressures to get more air. At Leeds they have succeeded in drawing in more air with quite low gas pressures.

Hygienic Investigation.

As Chairman of the Committee, Professor Smithells received quite an ovation when he spoke just before the conclusion of the discussion. He explained that the object of the inquiry is to improve the gas-fire, and to make it a more efficient means of consuming gas. The object, in short, is entirely and exclusively practical. It is for the makers of gas-fires to take advantage of the lessons of the research. The most important work in connection with the gas-fire awaits investigation, and that is its hygienic aspects. This he feels inclined to personally undertake single-handed. On hearing this, the members applauded; and in that perhaps Professor Smithells will find encouragement.

Throughout the report made by Mr. Smith and the discussion, the hall was well filled, which evinces the importance that the gas industry attaches to the work that is being conducted at the Leeds University in this connection. The number of members remaining showed considerable diminution, and the benches were somewhat sparsely occupied, during the reading and discussion of the next two papers. The one on the *agenda* by Mr. H. L. Doherty, of New York, on "Gas as a Universal Fuel," had not been received; so attention was next turned to

Gas Calorimetry in the United States.

The paper was full of information, and was by Mr. John B. Klumpp, of Philadelphia. In his absence the principal parts were read by Dr. Harold G. Colman. No one can be in a better position to tell us about this matter from the American standpoint than Mr. Klumpp, seeing that he is Chairman of the Committee on Gas Calorimetry of the American Gas Institute, whose first report was published in our columns on Dec. 29, 1908, p. 904 (a comment appearing in the same number, p. 888); while the second report was given in these columns as recently as Feb. 1 of this year. The subject as applied to America is a large one, and assumes various phases in different States, partly owing to the widely diverging character of the gas supplied —straight coal gas, varying percentages of water gas, and carburetted water gas unmixed with coal gas. Gas technicians and others in the United States have been giving as much attention to the question as we have been doing here; and calorific power regulation has actually now got a larger hold there than here.

The value of the paper lies not so much in the material of which it is composed, as in that it brings together the whole history of what has been done in America in applying a calorific test, and in investigation. But under the system of control by Public Service Commissions in America, there is just the danger that there will be striking discordancy in enactment, if great care is not exercised—they have a way of striking out on to lines of their own selection. The State of Wisconsin has adopted heating value in place of illuminating value as the standard; and within a mile from each distribution centre, it is ordained that the gas shall have a total heating value of not less than 600 B.Th.U., with a minimum that is never to be below 550 B.Th.U. In the State of Indiana, it has also been decreed that the supply of gas in cities of the first class shall not be less than 600 B.Th.U. No city can, of course, afford to be in any other category. These standards, however, are much too high for economical manufacture; and Mr. Klumpp is as strongly unfavourable to any haphazard enactment as we are on this side in the matter of fixing calorific standards. In his opinion, investigation should precede any decision as to the standard for any locality. Just as rigid is he against a dual standard of quality. He turns our attention to the State of New York, where there appears to have been some attempt to get near a uniform heating value by a variable illuminating power specification—viz., 16 candles for coal gas, 18 candles for mixed coal gas and carburetted water gas, and 20 candles for pure carburetted water gas. This has been the rule for some years past; but the Commission are now considering whether it would not be advisable to adopt some other standard of quality than illuminating power.

It is satisfactory to learn that the tests of the Calorimetry Committee of the American Gas Institute show that the efficiency of several types of calorimeter is at least 99·5 per cent.; and the Committee in arriving at this view no doubt carried out their tests with that precision as to detail that they lay down as necessary in their report, and as reproduced in the paper. The author takes the opportunity of discussing four sources of error referred to in Mr. J. H. Coste's paper before the Society of Chemical Industry, and reported in our columns; and he also turns an amount of comment on Mr. Holgate's recent articles in our pages. It is clear that there is a tendency in America to reduce the illuminating power; but that tendency has been so slow as to be almost inperceptible. This statement arrests attention: "The heating value of carburetted water-gas plants on the average has been as high as, if not higher than, the coal-gas plants; and consequently the mixed-gas plants have been manufacturing gas of a higher heating value." There is warning given against placing too much value on

calculations of heating power from gas analyses; and, in stating necessary conditions to accuracy, the author lays stress on (in calorimeters of the water-heater type) the inlet water being at the room temperature. There will be a large agreement with him as to the values being expressed as "gross" and not "net"—in fact, he regards the gross as the only proper and scientific method. The paper concludes with a specification of a calorimeter outfit and with full operating directions.

Gross v. Net Values.

Few took part in the discussion. As a matter of fact, there was little in the contribution that was open to dispute. Mr. Jacques Abady, Mr. Thomas Holgate, Dr. Davidson, and Dr. Colman were the speakers. Many of their remarks are not of the nature that one can indicate shortly. The matter of most general interest referred to gross and net values; and there was absolute accord on the part of all the speakers that the gross is to be preferred to the net. We have Mr. Abady pointing to the errors that arise in making a reduction from gross to net; but he holds that for experimental purposes the net cannot be neglected. But there is warning in his observation that, in the case of official tests, it would be a dangerous thing to be content to abide by the net result arrived at by the observer. Dr. Colman agrees; and it is a matter of regret to him that the net value has been adopted in the only statutory provision dealing with the subject in this country. On the whole, the errors of gross determinations are fewer than the errors of the net values. Further endorsement came from Mr. Holgate, who, however, pointed out that Mr. Coste, in his paper before the Society of Chemical Industry, referred to the fact that there are frequently errors of observation present in the gross figure, which are corrected when the condensation figure is deducted therefrom—thus leaving the net figure more accurate than the gross.

Regarding other matters, the speakers generally saw no reason, in measurement, for abandoning Centigrade for Fahrenheit thermometers. A practical point was raised by Mr. Holgate, with reference to the inlet water being at the same temperature as the atmosphere of the room, in reminding that there are occasions of rapid transition of temperature in a room when the temperature of the water in a tank in the room would not change with the same speed. He also thinks that, whenever possible, the analysis of the gas should be given, so that calorific power readings may be checked. It is interesting to learn that Dr. Davidson, comparing different calorimeters, finds the errors very slight between them; but all calorimeters require careful supervision so as not to allow sources of error to go undetected.

An Expert View and a Valuable Table.

Some illuminating views were contributed by Dr. Colman; and they are worthy of extended reference. He warmly supports Mr. Klumpp's contention that, in stating the calorific power of gases for purposes of definition, the gross value should be adopted, as this represents the total potential energy of the gas. The determination of the gross calorific power is, on the whole, subject to less experimental error than that of the net; in addition, two different net values are sometimes employed. Usually the practice is to find the net value by deducting from the gross figure the latent heat evolved from the steam produced in condensing to water at the boiling-point, together with the sensible heat due to the cooling of the condensed water from the boiling-point at the ordinary temperature. But in certain cases only the latent heat is deducted; and the figures obtained by the two methods would differ by about 1 per cent. with coal gas. The real use of the net value is chiefly in connection with thermodynamic investigation, where it is desired to know what amount of the total energy of the gas is evolved in the flame itself and was really available for production of flame temperature or for the development of pressure in a gas-engine cylinder. For such "thermodynamic" net values, only the latent heat of the condensed steam ought to be deducted, as the sensible heat given off from the condensed water in cooling to atmospheric temperature is not latent, but is really originally present in the flame as sensible heat, and is available for increasing flame temperature or development of pressure. The ordinary method of ascertaining the net value therefore gives results below the true "thermodynamic" net value; and this difference might give rise to trouble if the net value were adopted as the statutory one. The supposition often met with, that the net figure represented the amount of heat which can actually be obtained from a gas in practice, is quite untenable; for if the products of combustion pass away at such a temperature that the steam does not condense and evolve its latent heat, large quantities of sensible heat are inevitably lost at the same time, as the gaseous products of combustion and the excess of air also pass away at temperatures above that of the atmosphere—the loss in this respect being often greater than that represented by the latent heat of the steam. Dr. Colman also gave a table of the calorific powers of the various combustible gases present in coal gas, showing the gross, the ordinary net, and the "thermodynamic" net values of 1 cubic foot of each gas, measured moist at 60° Fahr. and 30 in. bar, by the use of which the calorific power of a gas can be calculated from its analysis in terms corresponding to those obtained by the calorimeter. He also agrees that in this country the calorific power should be recorded in the "all-British" units of B.Th.U. per cubic foot, and not in the hybrid units of calories per cubic foot, although he himself (as he does not forget) has been guilty in past years of using the latter.

Small Works Management.

It is not often at the meetings of the Institution that the managers of the smaller works have an opportunity of discussing matters that appertain more particularly to themselves and their duties, and of hearing the views on those questions of the managers of larger works. Such an opportunity was given in the paper by Mr. Fred. J. Ward, of Knowle, where he has been Engineer, Manager, and Secretary of the gas-works for a dozen years, and can now claim a make of just under 10 millions per annum. The paper was the last to be taken on Wednesday.

There is no doubt about it that Mr. Ward entertains some very advanced notions as to what should be the accomplishments of the chief official of an undertaking of the kind; and we are not disposed to dispute in any way his inferred contention that the nearer a man can approach to any high standard that he personally sets up, the better. But many a small undertaking with an output of 10 millions would have to go begging a long while for a manager, at the salary that could be afforded, if the directors or the committee insisted on only having a man reaching the capacity of the manager portrayed in the paper. In Mr. Ward's view, the offices of secretary and manager should be combined. The man appointed as manager should be an able accountant, and versed in company law and procedure. He should also be able to perform all the duties of engineer in the designing and preparation of drawings, &c., relating to extensions and reconstruction of works and plant. He should be able and willing to perform any hard practical duties, be expert in the use of tools and appliances, love work, be always in a condition to meet consumers and directors, always be a gentleman, and have a natural aptitude for steady, plodding, and unwearying work. A good knowledge of chemistry and physics is desirable. And with all must be combined sound common sense. These are the requirements picked out from various parts of the paper; and such a man, we say it with all respect to Mr. Ward, has all the qualities and qualifications required by the Chief Engineer and General Manager rolled into one of the Gaslight and Coke Company.

Mr. Ward is strongly in favour of the amalgamation of small undertakings, finding in such combinations economy in material purchasing and selling; and for the work of reconstructing, repairing, fitting, &c., such a combination can afford to keep a staff of specially qualified workmen. But the success of the scheme would rest largely in constant supervision; and, of course, the salary of the manager should be ample, and, if possible, be partly fixed by results. The qualifications such as Mr. Ward outlines should enable the manager to give thorough supervision; and he states a few of those points in the technical class to which special attention should be paid to ensure good manufacturing results. This must be said. Mr. Ward has done well for the little Knowle Company, as evidenced by a make of 12,307 cubic feet (with 11,855 cubic feet accounted for), without anti-dips, tar columns, retort-house governors, &c., and using South Yorkshire coal and one-third North Staffordshire. The cost into the holders is 13·29d. per 1000 cubic feet; and the charge to the consumers during his management has been reduced from 5s. to 3s. 6d. and 3s. 4d. The capital, too, has been brought down to £819 per million cubic feet, which, for such a small concern, is not by any means outrageous. What the

author has done, amid his limitations at Knowle, shows that it is a good thing for any gas manager, wherever situated, to set for himself a high standard, and to use his best endeavours and abilities to reach it.

One Objector, but General Approval.

From Ireland there came terrible denunciation of the paper—Mr. T. J. Reid, of Ballina (who was the first speaker), not finding anything in it helpful to the manager of the small gas-works, nor had he a good word for the Council for accepting it. The paper lacks reference to commercial matters. Some of the small gas-works in Ireland he claims have been far in advance of England in the matter of commercial method. Before free maintenance was thought of here, Mr. Reid was doing it in Ballina, and charging only for materials; and in some cases these even are not charged for. There was a little rub from the same quarter for the President, who, in his address, said "it is no use disguising the fact that gas companies have now more than ever become shopkeepers." Mr. Reid (turning to the President) remarked that gas men do not want to disguise the fact; it is their duty to advertise that they are out for business. Mr. T. Berridge, Mr. C. Stafford Ellery, Mr. R. W. Edwards, and Mr. S. O. Stephenson, were other speakers; and their congratulations to the author were of the most cordial kind regarding the results achieved by him. Mr. Berridge bore testimony to the quality—both illuminating and calorific power—of the gas being right. A little advice was given on the commercial part of the fittings and slot-meter business at Knowle. There was some inquisitiveness as to the character of the carbonizing plant used by the author; and amalgamation of small concerns (unless quite close together) was not altogether approved by certain of the speakers—Mr. Berridge, for instance, pointing out that the advantages of amalgamation are secured in the case of certain small undertakings for which he acts, by the purchase of material passing through his hands. Mr. Edwards, too, failed to see where the benefits of amalgamation are to come from in the case of Knowle, with such a working showing as is made in the paper. On the question of qualifications, Mr. Stephenson considers it more important for the manager of a small gas-works to devote himself to developing the business than to having any great engineering ability. It transpired that the Knowle Company, being a non-statutory one, do not pay much attention to illuminating power, but the calorific power of the gas they supply is about 530 B.Th.U. net. Knowle suffers the disadvantage, in one respect, of being close to Birmingham; the people, being mostly engaged in the city, purchasing there the gas-fittings they require. The secret of Mr. Ward's high makes, he thinks, is the method of working. He puts in a full charge; and at first has the pull rather heavy—decreasing it through the whole period of carbonization. By this means, a level retort-gauge and an even pull on the hydraulic are maintained. He has five retorts in a setting; but he would be better pleased if he had only four, and had them somewhat higher. Regarding the complaint of Mr. Reid that there was not more of the commercial element in the paper, the author pointed out that it was due to its curtailment at the request of the Council.

Save for the formal business towards the close of the sitting on Thursday, the whole morning was devoted to carbonization and kindred matters; and right away from ten o'clock until lunch time tempted, the attendance was good. The reports, papers, and discussions were excellent, and therefore attractive.

Carbonization Committee's "Report."

The proceedings opened with the presentation of the report of the Carbonizing Committee; and it was read by Mr. J. Ferguson Bell. To call what was submitted, as was done, the report of the Committee was in itself a misstatement; for a dozen opening lines constitute the whole of the report the Committee had to make; and this, if we may take the statement as representing the sum and substance of their work, is the confession of a single aim during the twelve months, and in that they have been disappointed. That is to say, they endeavoured to institute tests of the three best known systems of vertical retorts; but, through no fault of their own, they were unable to carry out the trial. Mr. Bell, however, saved the Committee from the odium of having no material to submit. He recounted the results of further investigations with respect to carbonizing with heavy and long-hour charges in horizontal retorts. But this is not a collective report by the Committee—it is a one-man investigation, and a one-man statement of the results.

Nevertheless this does not disparage in any way the value of Mr. Bell's work. His paper of last year (which obtained the distinction of the London Gold Medal), there is no gainsaying, gave a fillip to investigation wherever possible into the productive worth of changing working method in the retort-house; and the general confirmation that he now presents will be equally useful. There is one thing Mr. Bell is able to do that all gas engineers cannot accomplish through their works' limitations, and that is make trials of different weights of charge and hours of carbonizing, and register the results, under otherwise comparable conditions. Two retort-houses at the Litchurch works at Derby enable this to be done; and in these a week's run was made with Derbyshire coal of an average quality—the fine slack only being removed. In No. 1 house 12 cwt. charges were employed, with a carbonizing period of twelve hours; while in No. 2 house, charges of 8·21 cwt. were used, and the carbonizing period was eight hours. It was a substantial test; and Table II. gives the results at a glance. The production of gas per ton with the heavy charge working was (corrected) 12,091 cubic feet of 15·56-candle power; while the relative figures for the lighter charge were 11,820 cubic feet of 16·29-candle power—the respective sperm values being 645 lbs. and 660 lbs. The net calorific power, however, was respectively 554·6 B.Th.U. and 530·4 B.Th.U. The coke produced was of better quality on the large charge working; and the quantity used as fuel was slightly less—by 0·05 cwt. per ton of coal carbonized. The quantity of tar made per ton of coal was greater by 1·64 gallons. Rather more ammoniacal liquor and sulphate resulted. Mr. Bell describes the conditions under which the tests were carried out, and comments on the results. There is all the evidence required that the residual products—coke, tar, and sulphate—are improved by the heavier charge. As to the tar, we shall look with much interest for the results of the distillation tests. The ammonia shows an increase with the heavier charge of 1·39 lbs. per ton of coal carbonized—the total per ton being 29·89 lbs. It is somewhat curious that the sulphuretted hydrogen and the carbon bisulphide are somewhat higher in the heavy charges, as it is opposed to experience in other quarters, and likewise to expectation.

Coal Testing on the Large Scale.

The coal-testing plant, on the working scale at the Saltley works of the Birmingham Corporation, has been in operation now (as the "JOURNAL" records show) some five years; and through it excellent work has been done for the Gas Department, and valuable experiences have been gathered. The paper which immediately succeeded Mr. Bell's statement was composed of the fruits of the work on this plant; and it was presented by Dr. W. B. Davidson, upon whom falls the chief responsibility of the chemical work of the Gas Department. The paper was one of the finest technical contributions to the proceedings. The coal-testing plant is a complete gas-works in every detail; the carbonizing portion consisting of no less than four settings of six 20-feet retorts, 21 inch by 15 inch. Three beds are kept simultaneously at work; and the coal carbonized per day approximates 24 tons. The author discusses the comparative advantages and disadvantages of large and small test plants. Prior to this installation of large plant at Saltley, two small plants existed in the department; and the difficulty was to get any uniform records. In consequence, coal agents were often taken to task for inferior quality when no such deterioration existed. The results of carbonizing tests on the large scale are shown to greatly exceed those made with the small test plants—using, of course the same coal. Results of tests of a certain coal quoted in a text-book compared with results from the large test plant indicate the discrepancy and unreliability of laboratory carbonization of gas coal. Reasons for this are given in the paper.

The large test plant was adopted at Birmingham for certain purposes—to obtain information as to the true value of different coals that were offered, to carry out carbonizing experiments, and to check coal consignments. While the large test plant is superior to the small one, even under the best conditions the testing of gas coal does not admit of a high degree of accuracy. In the main, this is due to differences in the nature of the coal, and partly to inaccuracies of measurement and testing. Thus it is advisable to use the law of averages to eliminate errors of this kind by repetition of the tests from time to time. Regarding the valuation of

gas coals, the author gives a sketch of the basis of testing and valuation. This is where we get into a mass of detail that defies mere indication by a few words. Passing over it, a section of the paper is arrived at dealing with the standard of the quality of the gas; and Dr. Davidson is seen there as a progressive, with scientific and practical support for this particular feature of his creed. He shows that calorific power is a more dependable standard than illuminating power. When the legal standard of candle power of town gas is reduced to 12 or 14 candles with the No. 2 burner, coal may be valued, so far as the yield of gas is concerned, on a basis of calorific value with (say) 500 B.Th.U. net as the standard. From two years' tests of coals, and taking the results ranging between 16·5 and 17·5 candles and between 14·5 and 15·5 candles, together with their respective calorific values, he finds a decrease of 1 per cent. in calorific value corresponds to a decrease of practically 2 per cent. in illuminating power.

The paper is packed with information of this kind. We are told the effect of variations of 1 per cent. of different constituents on the calorific value and illuminating power of gas; and there is a comparison of gas manufactured with vertical retorts at high temperature with the product of horizontals. The illuminating power (No. 2 burner) of the gas from the verticals is given at 15·7 candles, and from the horizontals it is 0·2 candle higher; but the calorific value is respectively 524 and 506 B.Th.U. From complete gas analyses, the temperature of a bunsen flame is calculated with vertical retort gas at 2185° C., and with horizontal retort gas at 2095° C. Worth study, too, are the tabulated effects of altering the pressure in the retorts, and of other cognate investigation. The advantages of high temperatures are discussed, and with increases in the temperature, improvements in results have been realized. With the refractory material at present in use, it is not advisable to exceed an average retort temperature of 2100° Fahr., or a combustion chamber temperature of 2600°. Much depends as to what can be done in this direction on the use of better refractory material. And so we go on in this didactic paper, gaining information from every new section, till at the end there is hearty endorsement of the author's desire to thank the Birmingham Gas Committee for the permission they gave to the publication of the paper.

A closing remark of the author, apart from the paper, was that he does not know why it is that many of the advocates of the systems of carbonization keep back the figures as to their working. It would be a good thing if reliable figures could be obtained. It is proposed to instal a unit of one of the modern systems at Birmingham, in order to make comparisons.

Heavy Charges, and Source of Increased Yield.

It was a valuable discussion that took place on the report and paper; those participating in it being Mr. S. Y. Shoubridge, Mr. Charles Carpenter (Chairman of the Carbonizing Committee), Mr. John West, Mr. George Helps, Mr. Arthur Valon, Mr. W. B. Randall, Dr. Colman, Mr. Charles Hunt, Mr. S. Glover, Mr. J. P. Leather, and Mr. P. Holmes Hunt (Melbourne). Congratulations to Mr. Bell and Dr. Davidson were many. The discussion mainly turned on the experiences with heavy charges in the test plant at Birmingham and elsewhere. The President appeared a little envious of this plant, and wished it belonged to the gas industry. But the Birmingham Gas Committee, he acknowledges, deserve the gratitude of the industry for placing the results of the work upon it at the disposal of the industry. In Mr. Shoubridge's belief, it is the largest test plant in the world. He is not sure, however, that it is not too large for merely the analysis of gas coals; but for research work, it is admirable. Then we soon fell on to the question of heavy charges—Mr. Carpenter introducing it by expressing his opinion that Dr. Davidson has not been able to carry out his tests in regard to them under the best conditions, owing to hand labour; and Dr. Davidson later on admitted this. The results, as Mr. Carpenter pointed out, do not agree with the large-scale working of the South Metropolitan Gas Company, at whose works a million tons of coal have been carbonized now in full retorts; and there is no doubt about the increased yield. Mr. George Helps gave confirmation by reference to the working results achieved in numerous works. There is Mr. Randall, too, who claims a make (through reading Mr. Bell's paper last year) of 13,000 cubic feet per ton, with a sale of about 12,500 cubic feet, with fewer complaints from his consumers, and relief from the bugbear of naphthalene.

Where does the largely increased yield of gas come from, reflectively asks Dr. Colman? Either there must be a less weight of coke produced, or less water formed and condensed from the coal. He is convinced that the steam formed from the coal is decomposed to a greater extent with the full charge than when there is a large free space in the retort. The increased yield of gas, in his opinion, is more due to that source than to the one Dr. Davidson mentioned. Then that old carbonizer, Mr. Charles Hunt, rather controverted Dr. Colman's views. It seems to him that the increased yield from the heavy charge, or full retorts, is due not to the rise of temperature in the retorts, but to the reverse. Filling the retorts with coal, the bulk of the gas meets with a lower temperature, and is not decomposed as when there is a large free space for the gas to go through. Dr. Colman seems to think a great deal depends upon the decomposition of the steam; but, with a filled-up retort, a larger quantity of virgin liquor is obtained than with a partially filled one. This, in Mr. Hunt's judgment, disposes of Dr. Colman's theory. Following up the point, Mr. Samuel Glover thinks the improvement due to the fact that there is less loss of the hydrocarbons originally contained in the coal—in the way, for instance, of carbon deposit on the retorts. That there is something in this, is believed by Mr. Leather. What was formerly lost in the way of carbon on the retorts is largely gained in the newer practices. The extent of the real loss, he submits, cannot be judged by the weight of the carbon on the retorts. Mr. Bell also deposed to there being less carbon on the retorts, and less sulphur compounds and naphthalene produced, by the fuller charges. Bearing on the heavy charge, some interesting experiences came from Mr. P. Holmes Hunt. In Australia, the coal used for gas making varies considerably; some of it swells very much. He finds that he gets an undue pressure in his retorts if he packs them; and he has come to the conclusion that it is advisable to leave a little passage at the top of the charges.

Fuel and Calorific Power.

There were naturally many points raised on the fertile report and paper which cannot be noticed in this reference to salient features of the discussion. But two subjects more. As to the question of fuel consumption in retort-settings, Mr. Carpenter has discovered that jacketing the latter has a great beneficial bearing upon this. The calorific power question also cropped up again. Mr. Shoubridge introduced it by objecting to the sentences in Dr. Davidson's paper, suggesting that, when the standard of candle power of town gas is reduced to (say) 12 or 14 candles with the No. 2 burner, coal, so far as the yield of gas is concerned, might be valued on a calorific basis—say, 500 B.Th.U. net. Mr. Shoubridge was rightly opposed to it being understood outside that this was a fair calorific value to take for gas of a 12 to 14 candle power standard, tested by the No. 2 burner. As the result of a long record of tests at the South Suburban Company's works on gas made to a 14-candle standard, he regards 450 B.Th.U. as quite high enough to which to work. Mr. John West urges that test-burners and photometers should be done away with; and calorific power standards be adopted. Such a change would be a great advantage in technical work. Mr. Valon suggests that it would be a good thing for the gas industry if big corporations like Birmingham would take the lead in adopting a calorific standard, in lieu of the illuminating power one. Dr. Davidson disclaimed any intention of suggesting that 500 B.Th.U. net should be regarded as proper for a legal standard; it was only a suggested basis for the valuation of coal.

De Brouwer Plant at Sydenham.

"The Latest Installation of De Brouwer Stoking Machinery and Coke-Handling Plant" was the title given to the succeeding paper. It was by Mr. S. Y. Shoubridge, the Hon. Secretary of the Institution. The title of the paper might well have been "Economy of Modern Practices and Plant." Since Mr. Shoubridge's advent at the South Suburban Gas Company's works, they have been the scene of much progressive engineering work. Change has succeeded change; and at the back of it all, there has been one object, and that economy. And nothing in this way has been done at Sydenham during his tenure of office that has not had financial justification in the accounts. As to the change

that Mr. Shoubridge modestly describes in the paper, the economy of it is already fully assured. At Sydenham there has been a large experience with the De Brouwer stoking machinery and coke-conveying plant; and in the largest of all the houses (containing 26 beds of tens) the cost, from the unloading of the coal to the delivery of the coke on to the heap, has amounted to 8¼d. per ton of coal carbonized. Comparing this with 18½d. in the case of another house, containing eighteen beds of sevens and six beds of tens (all will ultimately be converted to tens), and with an arrangement of coal and coke handling and transmission that was responsible for heavy costs and the making of an undue proportion of coke breeze, it was clear that there was room for improvement and economy; and improvement there has been which will produce economy.

The framework of the compressed-air stoking-machines that were formerly in use has been utilized for accommodating De Brouwer machinery, worked by the compressed-air plant. But special interest centres in the coke-conveying plant, and Mr. Shoubridge's scheme for utilizing this in a manner that will facilitate coke stacking, and reduce the making of breeze to a minimum. There is novelty here. A De Brouwer conveyor has been adopted which, after it leaves the house, rises at an angle of 30° to a height of 27 feet, where it delivers the coke, over a screen, into the trough of the yard conveyor, which is 205 feet long. On each side of this yard conveyor is the feature of largest interest. This consists of a travelling and lowering conveyor for stacking the coke in the yard without breaking it, and for loading it direct into railway trucks. These lateral conveyors are each composed of a trough and De Brouwer chain, carried on a steel gantry, fitted with travelling wheels running on rails. One end of the conveyor is suspended on chains, and the other is hinged so that it can be raised and lowered, and thus avoid dropping the coke from a height. The coke can now be stacked in a large and almost level heap (except for the small peaks just where the coke is deposited) over a large area; and not as of old in a heap, triangular in section, with steep sides down which the coke was wont to slide, producing by the friction of its travel a plentiful supply of breeze. These transverse yard-conveyors are electrically driven; while the retort-house and the yard-conveyors are driven by the gas-engine that is used for the old conveyor.

We will not in this sketch describe the installation, in the old frameworks of their predecessors, of the De Brouwer projector and De-Brouwer-Jenkins discharging ram. But it may be mentioned in regard to the hopper feeding the projector, that a double rotary feeder has, in this instance, been adopted in order to avoid the irregularity occasionally experienced under former conditions, with the De Brouwer projector, when the coal happened to be fine and damp. Details regarding the whole of the work (which has just been finished) are given in the paper; and the estimate is that the over-all cost of carbonizing will be, from coal handling to coke heap, not more than 10¾d. per ton—representing a saving of about 8d. on the superseded plant and methods. Figures as to costs (including the maintenance of the coke-conveyors) are supplied in the paper. Savings are shown in all directions other than in maintenance, the increase in which, however, is submerged by the large final economy, added to which some credit must be taken for the smaller quantity of breeze made. This was really the only engineering contribution to the proceedings.

Coke Conveying Justified.

Details were numerous in the discussion; and for them reference must be made by those interested to the full report. Just as in the former discussion, this one was pointed with interest, to which contribution was made by Mr. J. Ferguson Bell, Mr. Edward Allen, Mr. D. Irving, Mr. A. C. Hovey, Mr. Edward Harman, and the President. The hot-coke conveyor had many good things said about it. With the heavier charges of to-day, it is an indispensable adjunct in works of any magnitude; and it has become, with time, a more economical means of doing the work. It is generally agreed, too, that the cost of maintenance has become less with the growth of experience. Mr. Hovey regards the chain conveyor an improvement over the old plate conveyor, which he thinks is becoming extinct. He also raised the question of friction and breeze; but, in respect of this, Mr. Shoubridge says his faith in the De Brouwer conveyor has increased with experience. By it the coke is carried forward, and does not roll about, and cause breeze by the pieces rubbing together. And the improvement described in the paper deals with one seat of an excess of breeze production. Mr. Irving had some critical remarks to make as to the power needed to drive conveyors at Bristol. The excellent work of the Temperley and the Telpher systems of conveying was referred to; but Mr. Shoubridge points out that such systems cannot be applied to the taking of coke direct from retorts under modern methods of working. They would only add to costs by delaying retort-house operations. There was congratulation to Mr. Shoubridge on his over-all working cost of 8¼d. per ton in the largest of his retort-houses. Some interesting figures were produced both from Bristol and Liverpool. Mr. Harman, however, thinks that the costs in different parts of the country cannot be properly compared on account of the variations in the wages paid. A better system of quenching coke than by water is desired by Mr. Allen. There was some talk of the system of coke smothering; but the time and the expense involved are against it, though the product is good.

Refractory Materials Inquiry.

We come to the final technical matter on the *agenda*. Quality and not quantity must be taken as the basis of judgment of the Refractory Committee's report which was presented by the able Hon. Secretary, Mr. F. W. Bywater. The Committee have been active, and have done useful work. Many inquiries and many pyrometrical tests have been made by them; and now, in this report, the fireclay, brick, and retort manufacturers have presented to them fairly representative maximum and minimum temperatures that their wares have to submit to in different parts of retort-settings and water-gas plants. If the works at which inquiry was made may be taken as representative of the whole, there is no question about there being a very fair amount of dissatisfaction abroad concerning the quality of the material supplied. A small proportion of the technical chiefs of the works state that they are satisfied with the materials supplied; only "fairly" satisfied is a slightly larger proportion; but the greatest number vote for dissatisfaction, or say there is room for improvement. An interesting point is the sizes of horizontal retorts used; and there is quite a considerable use made of 22 in. by 16 in. section. A goodly number of works employ irregular sizes. With so many using the 22 in. by 16 in. retort, and variations in the cross section being so small, the Committee are looking into the question of standardizing this size of retort. But there appears to be a very widespread objection to the standardization of retort patterns; and few would promise to adopt a standard pattern in the case of new work only. Still there is a preponderance of replies in favour of the preparation of standard specifications. We are to have these published in due course; and it is hoped engineers will make use of them next contract season. The establishment of an independent testing-station for gas-works refractory materials seems to be an idea that would meet with large acceptance. The Committee have had a conference with the representatives of the manufacturers, through the Society of British Gas Industries; and the manufacturers have signified their willingness to make the quality of their material equal to the required standards.

The discussion on the report was brief; and there is really not much to say about it here, as any little criticism was disposed of completely by Mr. Bywater. It may, however, be stated that Mr. J. W. Morrison thinks the specification proposed will be of much value in strengthening the hands of corporation engineers, who are handicapped by the craze for the acceptance of the lowest tender. It was pointed out by Mr. Bywater that the specification would not be directed exactly to defining what is a good material, but to showing what is not required, and therefore what is a bad one. The immense value of the report to makers was acknowledged by Mr. W. P. Gibbons, the Chairman of the Fire-Brick Section of the Society of British Gas Industries, and his remarks were endorsed by a fellow-member of the section—Mr. C. W. Thomas. The report, as Mr. Gibbons says, gives the makers information that they have been wanting for years; and he pledges the makers to further to the best of their abilitity the objects this inquiry has had in view. *Inter alia*, Mr. Samuel Glover spoke of the value of the temperatures collected by the Committee.

Next Institution Year.

The scrutiny of the balloting-papers revealed the expected. Immediately after this meeting, accession to the

presidency is made by Mr. Alexander Wilson, of Glasgow; Mr. R. G. Shadbolt follows him in the Senior Vice-Presidency; and Mr. J. Ferguson Bell takes office as Junior Vice-President. It was quite an interesting episode when that veteran Gas Engineer and Administrator, Mr. Robert Morton, rose and congratulated Mr. Wilson on the dignified position to which he has attained. Mr. Morton has known the new President all his life, during which Mr. Wilson has had to work very hard. But this is the "capping" of the whole. There was tremendous applause when Mr. Wilson rose to acknowledge his election, which was repeated when he invited the Institution to visit Glasgow for their next annual meeting. There was no refusing this, more especially when Sub-Convener Bailie Paxton (who will probably be Convenor of the Glasgow Corporation Gas Committee next year), with great cordiality, added, on behalf of the Committee, his support to the invitation.

Honorary Members.

The Presidents of the French and German Gas Associations and Mr. R. Forbes Carpenter were elected honorary members of the Institution. The mention of the nomination of Mr. Forbes Carpenter (whose great interest in the gas industry is recognized and appreciated in the whole of its professional ranks) was loudly cheered; and only as a mere formality was it necessary to put it to the vote.

The technical proceedings concluded with several votes of thanks; but deeply grateful as all are to those who have worked for the Institution, the relief on this occasion from long speeches, which do not add in any way to the feelings of gratitude, was welcome—more particularly as the sitting had extended from 10 a.m. till past 2 o'clock.

SOCIAL EVENTS OF THE WEEK.

Charming was the weather throughout the week; and London looked its best. All the visitors were deeply thankful; for the weather is the one thing that, on these occasions, caps the success of the whole annual meeting. If the weather is (to use a short but comprehensive term) bad, it does not leave its dire impressions and influences outside, but they get indoors, and permeate things all round. The reverse was the case during the past week; and outdoors and indoors brightness and the spirit that it imparts dominated. We did not hear a single regret that fate had decreed the ruling out of that ancient item in the programme—reception, dance, and so forth, that are looked upon by a few conservative ones as an indispensable appendage to the presidential office. It is nice to meet the President and his wife; but it is nice to meet them elsewhere—as on this occasion—than (in June) in the hot galleries of the Royal Institute of Painters in Water Colours. In London there is plenty to do, plenty to be seen, and plenty of amusement, without this old-standing item in the week's programme. Cannot someone, with initiative in these matters, suggest an alternative for immediate future Presidents, when the annual meetings are held in London? From conversation, it was gathered that the new public lighting in London—permanent and trial—engaged a good deal of the attention of the members; and the Japan-British Exhibition was a favourite *rendezvous* in the evening, where Mr. Edward Pilbrow had the pleasure of receiving innumerable visitors, from all parts, at the Exhibition stand of the Joint Gas Companies, in connection with which advertising display it is hoped the Hon. Secretary and Treasurer (Mr. F. W. Goodenough) will now get that "few hundred pounds" that are required to complete the amount of the estimated expenditure.

Masonic.

Among the engagements usually arranged for Gas Institution week, when the gathering takes place in London, is an "Emergency Meeting" of the Evening Star Lodge, No. 1719. As is customary, this was held on Monday of last week; and there attended more of those who are qualified than has been the case in any previous year. This may be accounted for by the fact that arrangements were made for the lodge to be held in the Grand Temple at Freemasons' Hall—thus giving many of the Provincial brethren an opportunity (which they had not previously had) of seeing the Headquarters of the Craft. Nearly 200 brethren accepted the invitation; and a very enjoyable evening was spent. After the usual formalities connected with the opening of the Lodge, the W.M. (W. Bro. W. A. Surridge) expressed the extreme pleasure he had in welcoming so large and distinguished a gathering, brought together from all parts of the country in connection with the annual meeting of the Institution; and he hoped the proceedings during the week would pass off to the entire satisfaction of everyone. He had little doubt but that this would be the case, in view of the fact that the President for the year was one so universally esteemed, not only in his professional work, but as a Mason, and one whom every member of the Evening Star Lodge was pleased to welcome. The "business" of the evening consisted of the initiation of the W.M.'s nephew, Mr. Rae Normand. In this, the W.M. was assisted by the other principal officers of the Lodge—S.W., Bro. Cyril G. Davis; J.W., W. Bro. Charles W. Offord; S.D., Bro. W. Edgar; J.D., Bro. E. G. Smithard; I.G., W. Bro. A. E. Croager; and the D.C., W. Bro. Walter T. Dunn. After the initiation, the lecture was delivered to the initiate by W. Bro. A. E. Broadberry, P.M. At the close of the Lodge, a banquet was served in the "Connaught Rooms;" and subsequently the "Variety Entertainment" provided was much appreciated.

At Croydon and the Japan-British Exhibition.

"A glorious day." That was the universal verdict on Friday evening, after some 440 happy beings had been the guests at Croydon of the Chairman (Mr. Charles Hussey, J.P.) and his fellow-Directors of the Gas Company, and at the Japan-British Exhibition of the President and Mrs. Helps, and the favoured ones of Old Sol. Long before the day had far advanced, it was forgotten that when we trooped on to No. 7 platform at Victoria Station of the L. B. & S. C. Railway, the morning was somewhat grey and chilly, so much so that umbrellas, "macks," and coats were well in evidence. Such material precautions were the superfluous luggage of the cautious. Just about eleven o'clock, the long "special," consisting of seventeen coaches—all first-class—steamed out of Victoria with its human freight; and from that time onwards there was not a blank space in the day. A hint might well be taken. This was, in numbers, the record outing of the Institution. Mr. Helps has not often deceived his Directors; but he has to plead guilty on this occasion—not designedly, but evidently through pinning his faith in this matter to precedents. But the Board is a model one; and they made no complaint, but were happy in the knowledge, that so many in excess of the expected in the professional ranks of the industry, and their ladies, desired to visit Croydon, and be the guests of the Company. The record is due to more than the exceptional popularity of Mr. Helps. It proves, we think, that an outing involving only a short railway journey (instead of two or three hours in a close compartment of a railway carriage) and a varied programme is appreciated. There was the short railway journey on this occasion; and there was the varied programme.

When West Croydon station was reached, the ladies alighted from the train; and they made a brave show—being well upwards of 100 in number. They were driven from the station to the centre of the town to inspect the Whitgift Hospital, which was founded by John Whitgift, Archbishop of Canterbury, in 1597. Ever kindly and ever genial Sir Frederick Edridge, who is one of the Governors, acted as cicerone; and Sir Frederick's affability gained for him the immediate regard of his fair charges. "We would not have missed this interesting treat for anything" was a remark that many a man heard when the ladies rejoined the larger party later at the Waddon works of the Croydon Gas Company.

The ladies having parted company from their male friends, the train proceeded to the Waddon Gas-Works, where a temporary platform had been provided by the sidings, but not a platform of sufficient length to accommodate at once seventeen coaches, and so only four or five at a time could be discharged. The first thing that attracted notice was the spacious vacant land, beautifully turfed and kept, on which the Company's employees take their recreation; the General Manager and Engineer holding strong belief in outdoor sport, and the provision of the means for obtaining it, as a cogent way of creating that *esprit de corps* which is such an essential factor in the good conduct of a large manufacturing establishment. Here the visitors were received by the President, the Chairman (Mr. Charles Hussey, J.P.), the Directors, Mr. A. Caddick (Mr. Helps's right-hand man at the works), Mr. W. W. Topley (the Secretary), Mr. W. J. Sandeman (Distributing Superintendent), Mr. Helps, jun.,

A General View of the Present Works at Waddon.

and most of the members of the official staff. We ought to mention here that Mr. Hussey's colleagues are Mr. Thomas Rigby (the Vice-Chairman), Mr. William Cash, F.C.A., Mr. P. H. Hall, Mr. W. J. Russell, Mr. Samuel Spencer, and Mr. Corbet Woodall. Looking round, the faces of most of these gentlemen were seen. After a few words of welcome from the President, the large party was divided into groups of about thirty—the first being headed by the President himself, the others by Mr. Caddick, and other members of the staff—and were conducted through the works; but so extensive are they that not much time could be spared in any one part.

A Glance Round the Works.

The works have been described from time to time in the "JOURNAL;" and the extensions in the order in which they have been made have been duly recorded. One striking thing about the Croydon gas-works is that the normal condition is cleanliness; and there is no doubt about it that the design and disposition of plant have much to do with this. Mr. Helps believes in plenty of elbow room. He believes, too, in buildings having good-looking exteriors and interiors. Refinement in appearance creeps in wherever it can be introduced. It all helps to an end. Thus in most of the buildings other than those immediately devoted to production and purification, a plentiful use is made of glazed faced bricks, which can be kept clean, and always maintain a place in a bright condition.

The works cover about 31 acres of ground, through which the L.B. and S.C. Railway Company's Wimbledon line runs, thus affording good facilities for the importation of coal, &c., and for the export of coke and other products. There are two sets of sidings, one running through the retort-houses at a height of about 14 feet from the ground, the other being on the ground level. These sidings are connected to the main line at both ends of the works. The coal-stores in all are capable of containing, under cover, 12,000 tons of coal. The works comprise two entirely distinct sections, each complete in itself, though at present the old (No. 1) section is in a transition state, and is gradually being converted from the old-fashioned type into a modern works, similar in many respects to the new or No. 2 section lately completed.

The retort-houses were first visited. No. 1 retort-house, built in 1865-6, still remains; and No. 2 house, built in 1875, has been considerably enlarged, and is now 200 ft. long by 72 ft. wide. Nos. 2 and 3 houses, making together the largest of all, will be dealt with presently.

In No. 2 house (which it was an advantage to see before being put to work), fifteen settings of ten retorts in five tiers have been erected by West's Gas Improvement Company, Limited, of Manchester, while stoking machinery, driven by compressed air, and made by the same firm, has been installed. The charging scoop is of the latest type, allowing of a charge of 11 cwt. per retort, while the coke is pushed out from one side by the firm's patent discharger. It was regretted that the makers were unable to complete the new scoop in readiness for the visit of the members.

The whole of the coal-breaking plant and the conveyors for dealing with both coal and coke are driven by electric motors; the electricity being generated by two 60 kilowatt dynamos, supplied by the Lancashire Dynamo Company, Limited, and worked by two 110 B.H.P. gas-engines. The electric plant is in a house erected at the south end of the retort-house, on the site originally occupied by the old sulphate plant, and which will form part of a large block of buildings, intended eventually to include lobbies, the mess-rooms, reading-rooms, lavatories, &c., for the use of the workmen.

The new coke plant was described quite recently in the "JOURNAL" (*ante*, p. 553). But it may be briefly stated that the hot-coke conveyor runs on one side of the retort-house only. It is 33 inches wide, and 12 inches deep, and of the West type. The hot coke is quenched during its passage through the house by water sprayed on it at a pressure of 60 lbs. obtained by an electrically driven two-stage Tan-Gyro pump. On reaching the end of the conveyor, the coke falls into a small hopper having a deflecting valve, which diverts the coke into one of two skips standing ready to receive it. These skips will each contain about 1 ton of coke. When one of them is filled, it is lifted by means of a 2-ton electric crane supplied by Messrs. Stothert and Pitt, Limited. In rising it engages with the deflecting valve, and diverts the coke falling from the conveyor into the empty skip standing ready on the other side. The crane runs on a gantry placed over the coke-hoppers, which are capable of holding about 500 tons of coke. The full skip is either emptied direct into the storage hoppers, into the hoppers of the coke-breakers, or else dropped into the yard should the hoppers be full. The hoppers are provided with two sets of outlets—one allowing the coke to fall on to two Marcus conveyors, by Messrs. Head, Wrightson, and Co., Limited, which carry it at the rate of 30 tons per hour each to trucks placed on a special siding—the breeze, &c., being removed by suitable screens during its passage. The second set of outlets allows the coke to fall over fixed screens into the yard for the purposes of the retail trade. These conveyors are of the jigging type, with a slow but irregular forward and backward movement. The Croydon installation is the first instance of their use for coke handling.

It is intended that the whole of the condensers, washers, and scrubbers in connection with the old section, shall shortly be removed, and replaced by more modern plant in a more convenient position. It is not necessary, therefore, to publish any description of this part of the plant. There are four exhausters, all by the Bryan Donkin Company, Limited. The two large ones, of 200,000 cubic feet per hour capacity, were erected in 1896. The smaller ones, of 80,000 cubic feet per hour capacity, were supplied in 1876 and 1880 respectively. The engines are of the compound condensing type; an ordinary surface condenser being used. The Lancashire boilers (by Messrs. Taylor, of Marsden) are 27 ft. long by 7 ft. 6 in. diameter, and are fitted with Meldrum's furnaces.

The purifiers are nine in number. The first four are 54 ft. long by 24 ft. wide, with 24-inch connections; the next four 24 ft. square, with 20-inch connections; and the last or catch-box, on Green's principle, 40 ft. long by 30 ft. wide, with 24-inch connections. The first set originally contained eight purifiers, 24 ft. square. But in 1893 they were converted into four of the present size. In 1900, the second set were coupled up by means of a Weck's valve, and now work as two large boxes, instead of four small ones. Oxide of iron is used in all the purifiers.

There are two station meters, one of 50,000 cubic feet per hour capacity, erected in 1875, and the other 100,000 cubic feet per hour capacity, erected in 1891—both being by the Gas-Meter Company, Limited. After leaving the meters, the gas passes to the valve-house, where it is collected in a large cylinder, 48 inches diameter, and thence is distributed to the gasholders. The outlets of the holders are connected up to a second cylinder, which has 30-inch outlets leading to the two governor-houses. By this means the whole of the valves, both inlets and outlets, can be actuated from one centre. An automatic bye-pass governor, by Messrs. W. & B. Cowan, is fixed between the two cylinders.

No. 3 retort-house was built in 1893, and was 196 ft. long by 72 ft. wide, with coal-store at the side, the same length,

View from Top of No. 2 Retort-House Coke Plant, showing Nos. 3 and 4 Retort Houses and Coke Plants, the Water-Gas Plant, the Boiler-House and Compressing Plant, the Booster Plant, and No. 2 Holder.

away as drawn from the retorts to cross conveyors and elevators, from which it drops on to jigging conveying screens, which, after extracting the breeze, divide the coke into two sizes, and drop it into hoppers as broken and large coke. From these hoppers, the breeze and coke can be loaded direct into trucks, which run on rails in a dock placed immediately beneath, or into carts. The plant is driven by gas-engines.

Over the compressor-house is an apartment in which is erected a "Criton" water-softening plant, and over this is placed a large tank capable of holding about 130,000 gallons of water. The whole supply of water is obtained from two artesian wells (one 400 feet, and the other 300 feet deep), and is forced into the overhead tank by compressed air on the air-lift principle.

After leaving the retort-house, the gas passes through a Colman cyclone, which brings about the separation of the heavy tar vapours. It is then (still hot) drawn through a Livesey washer, containing tar oil from the carburetted water-gas plant, which plays an important part in the elimination of naphthalene (as described by the President in his address). It is afterwards cooled in specially designed vertical water-tube condensers made by Messrs. Clapham Bros.

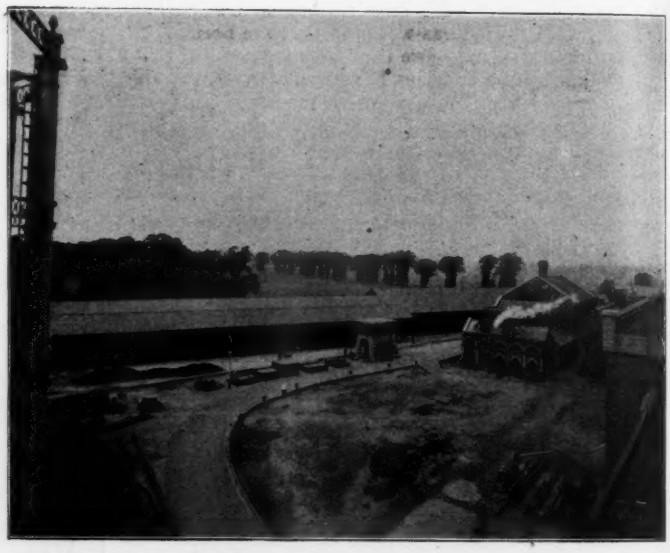
The exhausters and engines are two in number, each of a capacity of 180,000 cubic feet per hour. They were supplied by the Bryan Donkin Company, Limited, and are situated in one wing of a block of buildings, the middle portion of which contains two Lancashire boilers, 28 ft. by 8 ft. Space is left for a third. The opposite wing contains the various pumps which deal with the water, ammoniacal liquor, and tar, and also a condensing plant, to which the exhaust-steam pipes from all the engines, pumps, &c., are connected. After leaving the condensers, the gas travels through Livesey washers, where the remaining tar and some ammonia is extracted. It then passes through the Kirkham, Hulett, and Chandler "Standard" washers, where the remaining ammonia is washed out. It is noticed that the condensers, washers, and scrubbers are placed under cover in a lofty and spacious building—an arrangement which is somewhat novel in this country. The purifiers (of the Green type), with patent fasteners, are six in number, each 40 feet square by 6 feet deep, and in all of them oxide of iron is used. They are placed in a large covered shed, nearly 100 yards long.

The gas is afterwards measured in a "Rotary" station meter, made by Messrs. Thorp and Marsh.

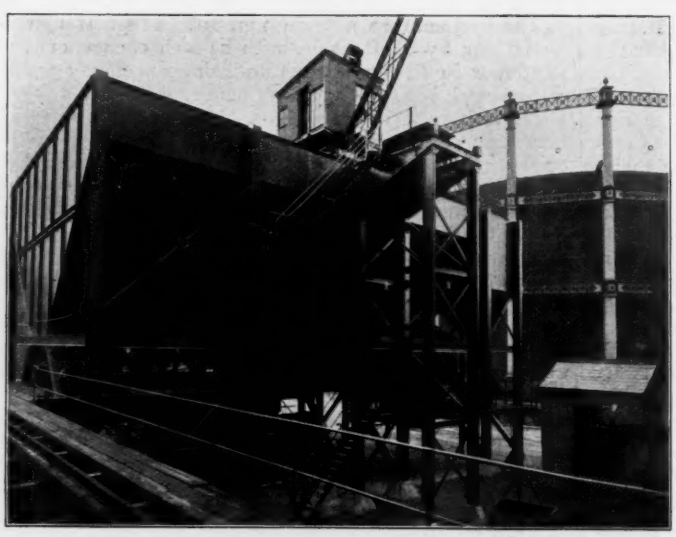
but 50 ft. wide. In 1904-5, this house was extended, making it altogether about 390 feet long. It contains 29 settings of eights on the regenerative system, with retorts, Ω shaped, 22 in. by 16 in. The house was originally worked by West's manual stoking machinery; but, with the erection of additional settings, machinery in which compressed air is the motive power has been substituted, with most satisfactory results. The change has necessitated the provision of apparatus for compressing the air; and this has been installed in a building opposite the water-gas plant, while a large boiler-house has been erected adjoining it, containing five boilers—some fitted with Victoria forced draught furnaces and others with the Varty or Northern fire-bars. Green's economizer is used to heat the feed water.

The coal is brought into the stores on the high-level railway, and is unloaded direct into the breakers beneath, after passing through which it is elevated and dropped into overhead hoppers on either side of the house, from which it is fed into the charging-machines. The house contains four sets of this elevating machinery.

The coke produced in Nos. 3 and 4 houses is either drawn direct into the producers, or is dealt with by De Brouwer conveyors, which carry it



View from the Top of No. 2 Retort-House Coke Plant—Showing No. 2. Holder and No. 2 Retort House.



Coal Storage Plant and Electric Crane.

The gas passes to the cylinder in the valve-house, which is common to all the gas made on the works, and from which it is distributed to the various holders.

The sulphate of ammonia plant was erected by the Chemical Engineering Company. It comprises the most modern improvements, including centrifugal drying apparatus and conveying machinery for storing. It is capable of making about 45 tons of sulphate per week.

There are three large underground tanks in which the tar and ammoniacal liquor are stored; while a third has been erected in connection with the new section, and is of somewhat novel construction. It is placed above ground, and is of annular type; the tar and liquor being pumped into the centre portion, the liquor eventually overflowing into the outside or annular space. The total capacity of the four tanks is about 650,000 gallons.

The Marcus Conveyor—Showing the Outlet Shoots from the Hopper.

The water-gas plant is by Messrs. Humphreys and Glasgow, and has a total capacity of about 3½ million cubic feet per day. Two of the fans in this plant are driven by steam-engines, and one by a Laval steam turbine. Separate purifiers, five in number (each 30 ft. long by 25 ft. wide), are provided for dealing with the gas produced. This is measured by two station meters (one on the rotary principle) on its way to the inlet cylinder in the valve-house, where its mixture with the coal gas is effected. There are two oil-tanks, each capable of storing 120,000 gallons.

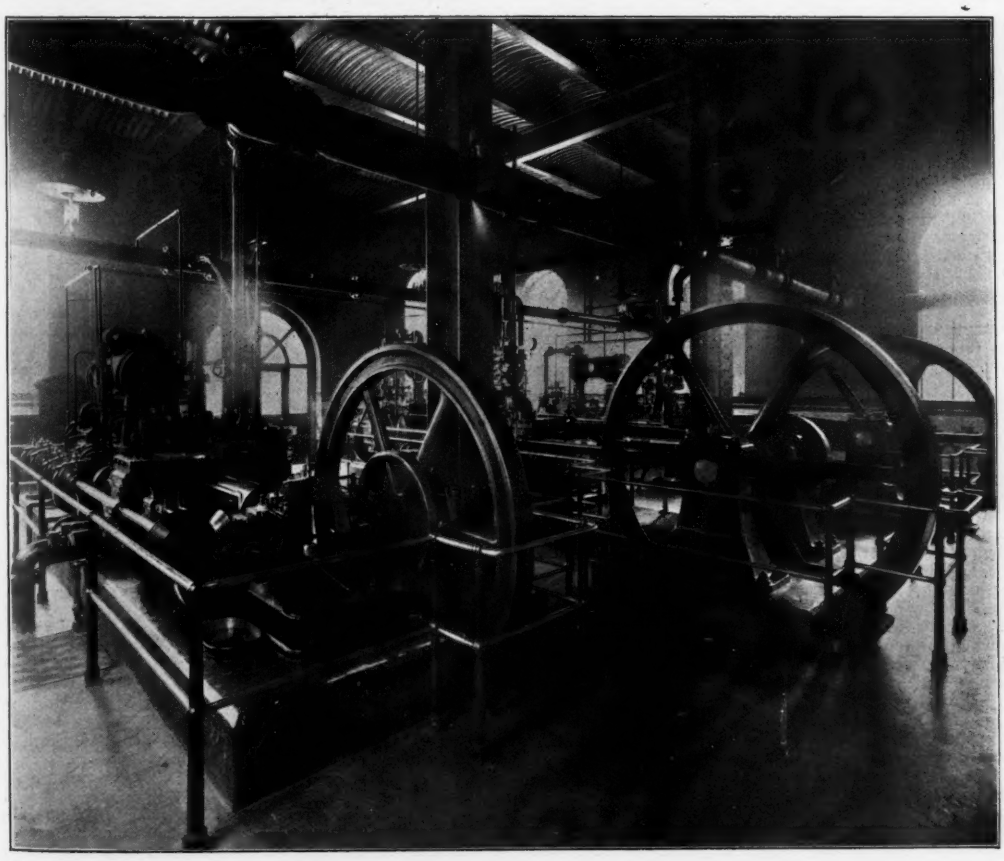
The governor-house in the old section contains three governors, which supply two 24-inch mains and one 12-inch; the other (built in 1906) containing three 24-inch governors, by Messrs. Parkinson and W. & B. Cowan, Limited. From the same cylinder to which these governors are connected runs a main under ungoverned pressure direct to the distribution station at Whyteleafe—a distance of over five miles. It is connected to a 12-inch main through a district governor for the supply of the Coulsdon district at Purley, and it also supplies the Kenley district through a similar governor.

In consequence of the large area (nearly 80 square miles) which has to be supplied, it has been found necessary to increase the pressure available for distribution from the holders. This was done by installing (in duplicate) pressure-raisers on the Sturtevant principle, driven by 60-H.P. steam-turbines on the Laval system. Each is capable of dealing with about 750,000 cubic feet of gas per hour.

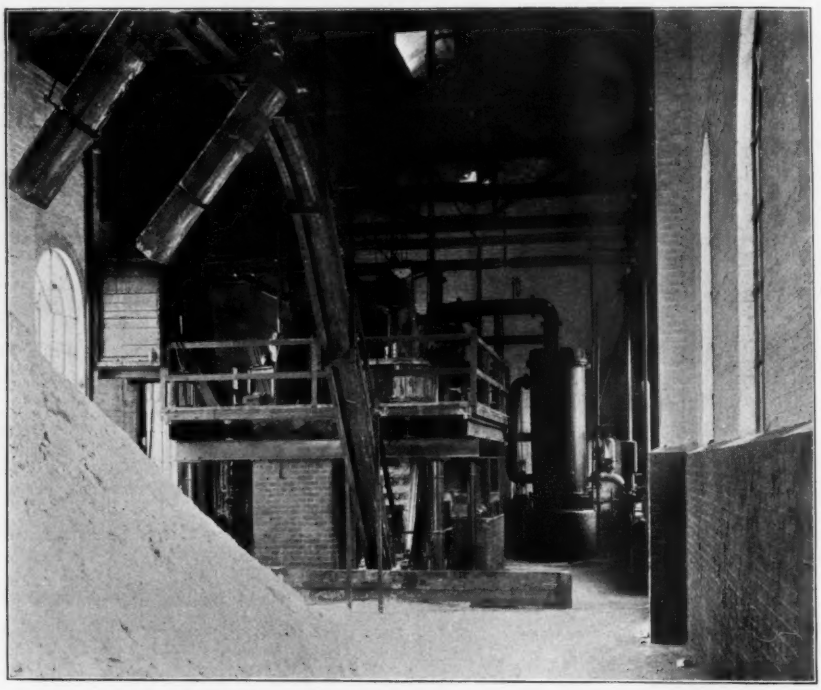
The gasholders are four in number. No. 1 (now used as a relief holder in connection with the carburetted water-gas plant) is 100 feet diameter, and will contain 400,000 cubic feet of gas. No. 2 has a capacity of about 900,000 cubic feet of gas; No. 3, of 1 million cubic feet; and No. 4, of 3 million cubic feet.

The Luncheon.

The inspection of the works finished, the visitors proceeded to the recreation ground where they found the ladies had already arrived; among them being Lady Edridge, and Mrs. and the Misses Helps. A move was at once made for the spacious marquee, in which the visitors were to be entertained to luncheon. Mr. Charles Hussey presided;



The Compressor House.



The Sulphate House.

and near to him were noticed Sir Frederick and Lady Edridge, the President and Mrs. Helps, the President-Elect (Mr. Alex. Wilson) the Senior Vice-President (Mr. R. G. Shadbolt) and Mrs. Shadbolt, the Hon. Secretary (Mr. S. Y. Shoubridge), the Mayor of Croydon (Major Fox), Alderman Tetley (the Chairman of the Leeds Corporation Gas Committee, representing the Leeds University), Mr. Corbet Woodall, Mr. W. Cash, Mr. S. Spencer, Mr. P. Hall, and Mr. W. J. Russell (Directors of the Company). The luncheon was a generous one; and appetites were good after the long morning's outing, sightseeing, and inspection.

The toast of "The King" having been honoured,

Sir FREDERICK EDRIDGE said, as an old resident of Croydon, he offered the visitors that day a hearty welcome, and expressed the hope that the ladies had been pleased with their visit to the ancient buildings of the town. With regard to the gentlemen, he could only say that he regretted time did not allow them to see many of the beauty spots in the neighbourhood; but probably they had seen one "beauty spot" in Waddon which had given them all great professional enjoyment. His duty was to propose the "Institution of Gas Engineers." He need not labour the fact that in all trade it had been found necessary to have institutions of this kind. They knew what kindred institutions had done for the trade of the country generally; and it went without saying that the great gas industry, which was a very complex one, having its factories over the whole land, in which some 150 millions of capital were embarked, and which catered for the comfort of a large percentage of the inhabitants of these islands, should have an able Institution to which the industry could look for guidance in the various matters connected with it. It appeared to him that one might also say that it was largely owing to the work of the Institution that the return on the capital which people had invested in the gas industry was so regular and satisfactory. For he was one of those who thought that the great progress that had been made in manufacture, distribution, and utilization was largely due to the interchange of expert opinion and experience that took place at the meetings of Institutions like this one. They had on the rolls of their Institution men whose names and fame were world-known. These were men who were not only eminent as gas engineers, but who intended to see that this particular trade at any rate should always stand in the forefront. They recognized the fact that we live in days of great competition, and therefore that no trade could stand still, but must be progressive. Not only did they understand that further improvements must be made in manufacturing, and further openings be made for their primary and secondary products, but they had taken the wise course of dealing with the education of the rising generation. The Chair of Gas Engineering and Fuel had been started and endowed at the Leeds University for the students of the gas industry. Under such conditions, he felt that the Institution were doing a great work, and that the industry, which had been so successful in the past, would be equally successful in the future. He coupled with the toast the name of the President. [Applause.] He was not surprised the announcement had been received with applause, because he ventured to say that the name of Mr. J. W. Helps in Croydon was a very good name to conjure with. Those of them who were members of the Territorial Army regarded him as one of their best recruiting sergeants; and they all knew that for many years past he had had in his mind the view that the rising generation should be educated so that they might turn out manly men. He had always been to the fore in education in Croydon. When it was suggested that technical education should be started in the borough, they at once looked to Mr. Helps as their leader, and ever since he had been the indefatigable Chairman of their Technical Education Committee; and he (Sir Frederick) said it, without fear of correction, that it was owing to him that their local secondary schools and polytechnics were, in a very large degree, in so satisfactory a condition as now. Those present knew Mr. Helps in his capacity of engineer much better than he (Sir Frederick) could possibly do. But he did know how his services were appreciated as an engineer of eminence and distinction—a man whose heart was in his work, and a man who had a head to carry it out. He understood that their President had earned, and very properly earned, the distinction he had received at the hands of the members; and during the time he had presided over their deliberations, it had been found that he was the right man in the right place. He hoped that for many years Mr. Helps would be spared to carry on his work in connection with the gas industry.

The PRESIDENT (who was received with loud cheers), in the course of his reply, remarked that he need not say with what pleasure he saw so many friends present on this occasion, and what pleasure it gave him to welcome them to the town in which he had lived for the past 26 years. He thought also it would be agreed by those present that it must have been a great pleasure for him to sit as he had done and listen to such (he thought) flattering words as those that had fallen from the lips of a gentleman whom he might call an old friend, Sir Frederick Edridge. It was a great pleasure for him (the President) to occupy the position he did that day at the head of the great industry like their own. It was a huge industry, employing something like 150 millions of capital, and using in the course of a year something like 16 million tons of coal, from which somewhere about 200,000 million cubic feet of gas were produced. These were certainly very large figures. Sir Frederick had also spoken of the good of competition. He (the President) thoroughly agreed with him. He remembered well the days when he was a young engineer in Leeds when the great electrician Jablochkoff brought out his electric arc lamp; and there was no doubt in his mind that that was what first started the true form of competition between the two lights. It was then only possible to get something like an efficiency of 2 candles for every foot of gas consumed per hour; but now it was possible to get anything up to 45 candles, and even a higher efficiency under some circumstances, per cubic foot. He thought it would be agreed that an industry which could bring that about might still exist, notwithstanding the fact that they could only sell 1 cubic foot to do, under ordinary conditions, what it took 10 cubic feet to do before. That was worthy the praise of the public generally, because it meant economy. He was glad to hear Sir Frederick allude to the efforts that had been made on the part of the Institution in connection with education. It was in order to memorialize the name of their great leader, Sir George Livesey, that they had established at the Leeds University the Professorship in Gas Engineering and Fuel; and he was glad to see present with them that day Mr. Alderman Tetley, who was intimately connected with the work of the Leeds University, as well as Mr. Smith, their Research Chemist, who was working in connection with matters dealing with the hygiene and efficiency of gas in connection with heating. It was absolutely important in these days that those who had to deal with the consumers should be educated, so that they understood not only the practical but the theoretical side of their work. Things were entirely different now from what they were a few years ago. The Institution were endeavouring to do their best, in order to assist in the supply of what the consumers required. He appreciated thoroughly all Sir Frederick had said concerning himself. He (the President) had lived in Croydon 26 years; and he had had the good fortune to work with a broad-minded Board of Directors, always keen, and always anxious, to adopt any methods or improvements that promised to be economical. Those members who had been round the works would acknowledge that the Directors had not spared expense,

while they had not been extravagant, in the effort to get the best that was economical, and a pleasure to those who had to work the plant.

Alderman TETLEY proposed the "Town and Trade of Croydon;" and, among his remarks, were congratulations on the excellent educational opportunities offered by Croydon. While on this topic he referred to the Professorship of Gas Engineering and Fuel; and said the University of Leeds had existed as a College of Science since 1874. During the whole of that time, the object of the Council had been to try to abolish the idea that great industries like this could be worked by mere rule-of-thumb knowledge. While they afforded opportunities for practical work, they had always before them the idea that a sound theoretical, scientific, and complete knowledge was absolutely necessary for ultimate and entire success. He was glad those who had been working in the matter of the Livesey Memorial Fund in the gas industry had been pleased to give to Leeds University this handsome foundation for the advancement of the great industry.

The MAYOR (Major Fox) responded, observing that, for the borough of Croydon, they might claim there was no better, no more cleanly, or more healthy town in the three kingdoms. A great deal of the credit for this result must be given to the Croydon Gas Company. They could at once see why this was so. While the Gas Company gave them the best possible light, they were followed, aided, and spurred on by the Electricity Committee of the Corporation. There was ample room in the town of Croydon for both of these institutions to go on and flourish—each one spurring on the other to gaining something better. Without light, they could not have health; and the Gas Company had done their best to emulate the light of the sun at midday. And they had succeeded very well.

Mr. ALEX. WILSON (President-Elect) said he had a pleasant duty in proposing the toast of "The Chairman and Directors of the Croydon Gas Company," their hosts that day. Their entertainment had been exceptional; and they were all delighted. They would carry away very happy memories of Croydon. The ladies had seen the historic sights of the town, and the members of the Institution had seen what had been very aptly described as a beauty spot in the way of gas-works. This was a point they ought all to keep in remembrance—that a gas-works besides being a place of utility, could also be made (in the way they had seen) a place of beauty. The works showed what could be accomplished by a competent and enterprising engineer; and Mr. Helps was happy in being associated with a Chairman and Board of Directors who were thoroughly alive to the needs of their business. An engineer could not carry on a works such as these without he was ably supported. The prosperity of the Company was well known. In 1851, they only sent out 10,700,000 cubic feet; and in 1909 1257 million cubic feet. A large factor in this rate of progress was seen in the fact that in 1886 the number of stoves on the hire system was 594, and by the end of December last year the figure had increased to 24,321, distributed among 35,644 consumers.

The CHAIRMAN thanked Mr. Wilson for the flattering way in which he had proposed the toast, and their visitors for the way in which they had received it and endorsed the words of the proposer. He voiced his own feelings and those of his brother Directors in saying how pleased they were to see them all, and especially so many ladies. Mr. Wilson had been kind enough to refer to the efforts of the Directors in supporting their Engineer. He (the Chairman) could assure all present that it required no words from any gentleman who had spoken to raise Mr. Helps in the estimation and good fellowship of the Directors of the Gas Company. Their Engineer never put before them anything that he did not thoroughly believe in; and when he could show the Board any way in which, or anything by which, they could reduce the cost of manufacture, they were always ready to adopt it. The Chairman then proceeded to give an historical account of the inception and progress of the Company. Speaking from knowledge during his connection with the Board, it had always been the policy of the Directors to sell gas at the lowest possible price. It was now 2s. 8d. per 1000 cubic feet; and they hoped before long they would be able to reduce it again. He saw by the records that in 1847 the Manager and Collector was paid £120 a year; he was afraid they would have to put another "0" on that to retain their present Engineer. But of this he was confident—the present Board would always make it worth their Engineer's while to stay with them. In 1890, his (the Chairman's) fellow-Directors did him the honour to elect him as their Chairman; and they had done him the honour of keeping him in the position. During that period the output of gas had trebled. This was not due altogether to Mr. Helps or to the Chairman and Directors, but to the fact that the population had increased enormously.

Mr. CORBET WOODALL also responded, on the invitation of the Chairman. He said he valued the opportunity because the other day, when Mr. Helps delivered his admirable presidential address, he (Mr. Woodall) was asked, without notice, to move a resolution expressing the thanks of the members for it. He got up with the most excellent intentions of fulfilling that duty; but he found himself thinking about the address itself, and not about the writer—the result being that he sat down without saying one word with regard to Mr. Helps in his capacity as the author of the address. He did appreciate that deliverance very highly; as he was sure did all the members. It contained material that would be a lasting benefit to the industry. Those who had watched Mr. Helps's work knew how devotedly he had given himself to the service of the Croydon Gas Company; and at the same time they knew how great had been his services to the industry. One of the features in the policy of the Directors of the Company had been to find the best man as their technical head, and having found him to trust him. [Applause.] In regard to the works, they had tried to make them such as the men themselves might be proud of; and he was sure the success and prosperity of the Company had been advanced thereby.

Soon afterwards, the large company assembled on the bank of the railway siding, and were photographed. A few minutes later they were aboard the train, and were speeding their way to the Japan-British Exhibition. There they were entertained to tea by Mr. and Mrs. Helps in the Garden Club. Subsequently, the President-Elect (Mr. Wilson) proposed a vote of thanks to Mr. and Mrs. Helps; and, in his remarks, spoke of how great a factor the President himself had been in the success of the meeting. The weather had also done its part. He ventured to hope that it would favour them at Glasgow next year. The President, on behalf of Mrs. Helps and himself, thanked Mr. Wilson and the members; and wished them all a hearty "Good-bye." The members and their ladies then roamed about the exhibition, indulging themselves fully in the sights and the music, and not a few found their way to the Gas Exhibition. One thing must be said respecting the arrangements for the day. The President has a reputation for organizing ability; and he was admirably aided by Mr. Dunn. It was in everyone's mouth that the arrangements, to the smallest detail for comfort, were as perfect as it was possible for ingenuity to devise.

Personal adieus were made later in the evening; and then we left the exhibition to enter upon a fresh year's work under the presidency of Mr. Wilson. May that year be, in the largest sense of the term, successful.

GENERAL REPORT.

The Annual General Meeting of the Institution opened last Tuesday, at the Institution of Mechanical Engineers, Storey's Gate, S.W.—Mr. JAMES W. HELPS, M.Inst.C.E., of Croydon, the President, in the chair. There was a good attendance, including many ladies.

The National Loss.

The PRESIDENT said the memory of the great loss which the nation had suffered since the members last met in that room was too fresh to allow him to open the meeting without referring to it. He did not wish to dwell upon the subject, as so much had been said in reference to it. He need only, he thought, read the formal resolution which had been drawn up, and which he would ask the meeting to pass by rising silently. It would then be engrossed and sent to the Home Secretary. It was as follows:—

> That the members of the Incorporated Institution of Gas Engineers, in general meeting assembled, desire to place on record the profound sorrow they feel at the death of His Majesty King Edward the Seventh. They recall with gratitude the innumerable instances of the practical interest which their late beloved Sovereign, throughout his beneficent reign, evinced in the progress of engineering science, particularly in many of those branches relating to the industry they represent. To the Queen Mother and the other members of the Royal Family they beg to tender their respectful assurance of deep sympathy in their bereavement, and to His Majesty King George the Fifth their dutiful and loyal congratulations on His Majesty's accession to the Throne; praying that with the blessing of God he may long be spared to graciously rule over the people of this country, and those of the British Dominions beyond the sea.

Mr. ALEX. WILSON (Glasgow) seconded the motion, which was carried unanimously in the manner indicated by the President.

Confirmation of Minutes.

On the motion of the HON. SECRETARY (Mr. S. Y. Shoubridge), the minutes of the last annual meeting were taken as read, and confirmed.

Appointment of Scrutineers.

Mr. Thomas Berridge (Leamington) and Mr. Joseph Davis (Gravesend) were appointed Scrutineers.

The Annual Report

[See "JOURNAL" for May 31, p. 549.]

The PRESIDENT then moved that the annual report of the Council, and the accounts, be received and adopted; remarking that if anyone wished to make any observations upon them, it would be open to him to do so.

Mr. E. ALLEN (Liverpool) seconded the motion; and it was carried unanimously.

Presentation of Awards.

The PRESIDENT said he had now to perform the very pleasant task of presenting the prize medals to gentlemen who read papers at the last meeting, and to whom they had been awarded. The "London" Gold Medal (presented by Mr. H. E. Jones) had been awarded to Mr. J. Ferguson Bell,

for his paper on "Carbonizing." Everyone would agree that the work and investigations of Mr. Bell were no small item in the progress which had been made of late years in carbonizing matters. They would all hope that Mr. Bell would go on to further heights, in appreciation of the honour now conferred upon him.

Mr. BELL (Derby) said that he must cordially thank the President for his very kind and appreciative remarks. It was a great privilege and honour to be allowed to submit a paper to the Institution; but it was a much greater honour to receive this gold medal, which he should treasure and look upon with great gratification. If he could do anything more to further the interests of the Institution, it would be his pleasure, as well as his duty, to do so.

The PRESIDENT next presented the Silver Medal to Dr. Rudolf Lessing, for his paper on "Carbonization in Chamber Settings."

Dr. LESSING said he was much surprised at hearing that the Council had awarded him this medal, which he never expected, especially as his paper was not at all of the character of Mr. Bell's. It was not what he should call an original paper, but was merely intended as a chronicle of events; and what little of his own work was incorporated was only of theoretical nature. He was glad he had included a certain disclaimer, for events had proved that the methods of carbonization he brought forward had not, so far, been adopted in this country, and had not made any really great strides during the past year. On the other hand, he believed the practice of bringing before those interested in the gas industry the improvements which had been made elsewhere had been shown to be justified, for their old friend the horizontal retort had made enormous progress under the influence of imminent competition, and was shown to be quite capable of coping with modern requirements.

The PRESIDENT then presented the Bronze Medal to Mr. Robert Watson, of Doncaster, for his paper on "Some of the Advantages and Disadvantages of a Hot-Coke Conveyor." This was, he said, a particularly practical and useful paper; and Mr. Watson's industry in collecting so much information fully entitled him to the award.

Mr. WATSON, in thanking the Council for the honour that they had conferred upon him, which he thoroughly appreciated, said the object of the paper was to suggest that the mechanical conveyance of coke was applicable to works of small magnitude almost as much as to those of larger size. And in view of the fact that in future heavier charges were likely to be in vogue, with the result that the coke would come out of the retort more in bulk, it did seem as if the day of the barrow was drawing to its close.

Welcome to Friends from a Distance.

The PRESIDENT said he desired to offer a word of welcome to their friends from a distance, whom they were glad to see among them. He would first mention Mr. Holmes Hunt, the President of the Victorian Gas Managers' Association, whose name and work were well known in the gas world. There were also present two gentlemen from the United States—Mr. Nettleton and Mr. Burgi—whom they heartily welcomed. If he did not mention the names of others, it was simply because he did not know them; but he must express his pleasure at seeing among them Professor Smithells, of the Leeds University, whom they might almost reckon as one of themselves.

President's Address.

The PRESIDENT then delivered his Inaugural Address, which was given in the "JOURNAL" last week (p. 682). At its close,

Mr. CORBET WOODALL said he had been asked to move a vote of thanks to the President for his address; and it was also intimated that he should add to it a proposal that the Council be requested to appoint a Committee to consider the suggestions contained in the address, and prepare a report for presentation to the members dealing with the future work of the Institution in general. He regretted not having heard the whole of the address; but he had heard enough to make him, while warmly admiring it, to somewhat question the conclusion arrived at. The President spoke of the great changes which had taken place in the industry, especially during the last twenty years, and drew the conclusion that the Institution and the industry generally had not sufficiently appreciated these changes, and had not risen to the necessity for meeting them. It seemed to him that the address itself was a satisfactory answer to this charge. As he came to the meeting, he was wondering where Mr. Helps would find subjects for his address; but as the President proceeded, he felt not only how greatly had the industry changed, but how the men who carried it on, with the President at their head, had changed with it and how keenly they were facing the problems which arose in the course of their work. When he looked back, not fifteen or twenty years, but very much farther, it seemed to him that the gas world was a new world altogether. Things went fairly smoothly in the old days; but it was delightful to him to find how, with the immense increase in the difficulty of the problems to be faced, the men entering the profession were proving themselves equal to them, and were facing them in a very successful manner. He wondered at first why he had been asked to move this resolution. But when the President, near the end of his address, spoke of the necessity not merely of dealing with the work in the gas-works but also with the selling of gas, and making known to the general community the advantages of gas and the uses to which it could be applied, he felt that, as he represented a Company who had done their share in this direction, it was perhaps appropriate that he should move the resolution. He could not agree with the President if he meant his observation about dividends being made in the retort-house to be any reflection on the old adage, because he did not think that attention could be better bestowed on any part of their work than the developments and improvements of carbonizing. At the same time, he recognized fully the point that it was in the direction to which a large portion of the address was devoted that they must look for a continued growth of the gas industry. He felt sure that if the Institution was able to show, by the work it did, that it was worthy to carry on the widely extended usefulness to which the President had referred, there would be no considerable difficulty about finding the funds. If it could be shown that the Institution was equal to the duties which had been suggested, he thought that directors and others would appreciate it, and the money would be forthcoming. He should be sorry to think that the gas industry of England fell behind their friends in France and Germany, where the amount of money placed at the disposal of Institutions similar to their own, was vastly greater than it was with us. They had shown a keenness, outside the mere meetings of Gas Associations, which he thought had been lacking here. He hoped that the suggestions now made would not be simply applauded and forgotten, but that in the near future some effect would be given to them in such a manner as had been indicated.

Mr. JOHN WEST, seconding the motion, said that those who knew the President anticipated something good; but he had given them more even than they had expected—something far superior and very far reaching. Therefore it was thought desirable that the Council should consider seriously the suggestions which had been laid before them, and take some action upon them. He would not attempt to go into the suggestions, but they would be very valuable if properly carried out; and a Committee might very properly consider them, and report to the members. In this way he felt sure something might be done to bring the Institution more to the front; for, though a great deal had been done in this way, there was still much which might be done.

The motion was put by Mr. Woodall, and carried by acclamation.

Mr. E. A. HARMAN (Huddersfield) said if it had not been too late he should have suggested an amendment, because while he heartily agreed with the first part of the resolution, he was not sure that the subsequent portion would meet with general acceptance. At any rate, he thought it premature to pass a resolution of this sort in a hurried manner. He should like to have some opportunity of suggesting the division of the resolution.

Mr. WOODALL said he felt no disposition to alter the terms of the resolution; but if there was a general feeling that it should be amended, no doubt there would be an expression to this effect. After a pause, he declared the resolution had been carried without a dissentient.

The PRESIDENT thanked the members, and especially Mr. Woodall and Mr. West, for their kind appreciation of his efforts. He had only one object in view in preparing the address, and it was to try and secure for the working of the Institution more support all round than it had hitherto received. He knew Mr. Woodall had in mind the kindly contributions of the directors and committees of gas companies and gas undertakings on various occasions when they had been approached. But he could assure him that where

one met them in this way there were three or four who absolutely refused. He thought it very important that the whole matter should be generally considered, and that every company should take its share in providing the necessary fund for carrying out the work of the Institution. He need not say more now, but would only thank the members for their kind y approval, which he much appreciated.

Reading of Communications.

The reading of papers, &c., was then proceeded with. They were taken in the following order:—

Tuesday.—"Public Lighting from a Municipal Point of View," by Mr. JACQUES ABADY.

Wednesday.—Report of the Gas-Heating Research Committee. "Gas Calorimetry in the United States," by Mr. J. B. KLUMPP. "The Management of Small Gas Undertakings and Works," by Mr. F. J. WARD.

Thursday.—Report of the Carbonization Research Committee. "Experiments in Carbonization on the Birmingham Coal-Test Plant," by Dr. W. B. DAVIDSON. "The Latest Installation of De Brouwer Stoking Machinery and Coke-Handling Plant," by Mr. S. Y. SHOUBRIDGE. Report of the Refractory Materials Research Committee.

The Benevolent Fund.

On Wednesday, the annual meeting of the donors and subscribers to this fund was held. A report of the proceedings will be found on the next page.

The New Officers.

The PRESIDENT announced the result of the election of office-bearers for the current year, as follows:—

President.—Mr. Alexander Wilson, of Glasgow.

Vice-President.—Mr. J. Ferguson Bell, of Derby. [Mr. R. G. Shadbolt, of Grantham, is Senior Vice-President.]

New Ordinary Members of Council.—Mr. F. J. Bywater, of Birmingham; Mr. F. W. Goodenough, of the Gaslight and Coke Company; Mr. W. R. Herring, of Edinburgh; Mr. Herbert Lees, of Hexham.

Auditors.—Mr. J. L. Chapman and Mr. Ernest W. Drew.

Hon. Secretary.—Mr. S. Y. Shoubridge.

The following candidates for membership of the Institution were elected.

MEMBERS.

Armitage, Cecil R., Morecambe.
Armstrong, James, Ilfracombe.
Baillie, William, Keighley.
Brock, William E., Denbigh.
Blakey, Harry, Shipley.
Brooks, Alfred E., Ascot.
Campbell, John M., Margate.
Carpenter, Bertram A., Sheerness.
Clarry, George, Manager and Secretary, Cardiff Gas Company.
Cockey, F. G., Tramway Company, Bahia, Brazil.
Codgbrook, C. A. W., Berkhamsted.
Davidson, William B., Chief Chemist, Birmingham Gas Department.
Davies, D. J., Hirwain, Glamorgan.
Elliott, Arthur H., Engineer-Chemist to the New York Consolidated Gas Company.
Franklin, Thomas E., Barry.
Franks, Ernest A., Ferndale, Glamorgan.
Gaunt, J., Aberystwyth.
Harrison, R., Monaghan.
Kennedy, M. J., Palmerston North, N.Z.
Madden, H. D., Engineer, Cardiff Gas Company.
Mosley, L. D., Seaford.
Murray, S., Pontycymmer.
Nelson, R., East Hull Gas Company.
Robb, James, Beaufort, Breconshire.
Swain, Edward H., Pontypridd.
Taylor, B. L., Colonial Gas Association, Melbourne.
Taylor, J., Mossley.
Tervet, W. P., Devonport.
Towers, Cyril, Brentwood.
Ward, Alfred J., Bute Gas Works, Cardiff.
Watson, C. A., Charters Towers, Queensland.
White, F. C., Treharris.
Wilkins, P. S., Godalming.
Willoughby, John H., Santos, Brazil.
Woodcock, T. H., Stroud, Glos.

ASSOCIATE MEMBERS.

Barber, Leonard G., Assistant-Manager, Oriental Gas Company, Calcutta.
Browning, R. G. S., Assistant-Engineer, Neath.
Chamberlain, Horace, Assistant, British Gas Company, Hull.
Dougall, Percy, Newquay, Cornwall.
Evans, Owen, Assistant-Manager, Wrexham.
Halstead, John W., Assistant-Manager, Walsall.
Helps, Reginald A., Assistant-Engineer, Jersey.
Hogg, Walter T., Assistant-Manager, Mitcham.
Jolliffe, Wilfred E., Assistant, British Gas Company, Hull.
Jones, Charles H., Assistant-Engineer, Gavette Gas-Works, Genoa.
Pearce, Frank J., Assistant, Bath.
Pelley, Charles A., Assistant, Teignmouth.
Port, Horace N., Works Engineer, Woodstock, Cape Town.
Robins, Walter T., Assistant Lighting Engineer to the Great Western Railway.
Sumner, Arthur W., Assistant-Manager, Grays.
Wayte, William H., Distribution Superintendent, British Gas Company, Norwich.

Honorary Members.

The PRESIDENT moved the election as honorary members of the President of the Société Technique de l'Industrie du Gaz en France, the President of the German Association of Gas and Water Engineers, and Mr. R. Forbes Carpenter, the late Chief Inspector under the Alkali Acts.

Mr. S. GLOVER, in seconding the motion, said Mr. Carpenter was a very old friend of his, and it gave him great pleasure to second his nomination, because he had shown throughout his official career very great interest in the gas industry, and in the related industries of sulphate manufacture, &c.

The motion was carried unanimously.

Place of Next Meeting.

Mr. ALEXANDER WILSON said he first desired to thank the members for the honour they had done him in electing him President, which he highly appreciated. He also recognized the responsibilities of the position and the work it entailed. But he would endeavour to maintain the high standard set by Mr. Helps and the other eminent men who had preceded him; and, with the assistance of his colleagues on the Council, he would do his utmost to further the best interests of the Institution. With regard to the meeting-place next year, he cordially invited the members to Glasgow.

Bailie PAXTON said he had great pleasure in seconding the motion. The present was his third appearance at the meetings of the Institution, and his principal mission now had been confided to him by the Corporation of Glasgow, and by the Lord Provost himself, to extend to all the members a very cordial invitation to the city of their adoption—Glasgow—this time next year. They were very interested just now in Glasgow in purifying the air, having succeeded in purifying the Clyde; and, if the Institution met there, they would help forward this crusade. He assured them that in no place would they be more warmly received. Under ordinary circumstances, and if his constituents showed their usual good sense, he would be the Convener of the Gas Committee, and would have charge of the arrangements; and he promised the members personally, on behalf of himself and his colleagues, that nothing should be left undone to make the visit a pleasant one.

The PRESIDENT said the Institution were deeply indebted to Bailie Paxton and the Corporation of Glasgow for their kind invitation. It seemed to him hardly necessary to put the motion; but, as a matter of form, he would do so.

The motion was unanimously carried.

Mr. ROBERT MORTON, as one who had known the new President all his life, expressed the hope that he might be allowed to congratulate him on the position he had attained.

A General Advertising Fund.

The PRESIDENT said he had received a letter from the Secretary of the Tottenham and Edmonton Gas Company, to the effect that the Company approved of a proposal which had been put forward to form a general fund for advertising the advantages of gas for all purposes, and undertook to contribute 2s. 6d. per million cubic feet sold (provided fifty other gas undertakings would enter into the same arrangement), and were prepared to guarantee this subscription for a period of three years. He hoped that this excellent example would be shortly followed, not only

by the fifty undertakings stipulated for, but by practically the whole of the gas-works in the United Kingdom.

Votes of Thanks.

Dr. COLMAN proposed a hearty vote of thanks to the President, not only for his services in the chair, but also for the work he had done for the Institution throughout his year of office. They all knew how the duties of this post were increasing; and, apart from the hard work of the week, there was the constant attendance to the business coming before the Council. Moreover, it was deemed the duty of a President in these days to visit, as far as possible, each of the Affiliated Associations during the year; and Mr. Helps had well carried out this work. Beyond this, they all felt personally indebted to him for the kind assistance he was always ready to give to any member who applied to him. The resolution also included thanks to the Council and the Honorary Secretary (Mr. Shoubridge).

Mr. KENDRICK said his late experience in all three fields in a somewhat similar constituency made him thoroughly appreciate the work which had been carried out; and he heartily seconded the resolution.

The motion was put, and carried unanimously.

The PRESIDENT thanked the members and Dr. Colman, not only for the kindness they had all shown, but for the attention paid to the business, and the very satisfactory way in which they had come to listen to the papers. He should always look back on the week of the meeting as one of the most pleasant he had ever spent. He also returned thanks on behalf of Mr. Shoubridge and the Council.

Mr. E. ALLEN (Liverpool) proposed a vote of thanks to the Chairman and Directors of the Croydon Gas Company, for their invitation to inspect the works, and for the hospitable arrangements they had kindly made for the reception of ladies and members; also to the Council of the Institution of Mechanical Engineers, for their kindness in granting the use of the room for the meetings.

Mr. T. GLOVER (Norwich) seconded the motion; and it was carried unanimously.

Mr. D. H. HELPS (Reading) proposed a hearty vote of thanks to the authors of the papers, to the Research Committees on Gas Heating, on Carbonization, and on Refractory Materials, to the Scrutineers, and to the Auditors. He said the members would all agree that the papers they had heard had not only been most interesting, but would be of very great value to the industry. The large and continuous attendance at the meetings showed how much their efforts had been appreciated.

Mr. B. W. SMITH (Walsall) seconded the motion, which was carried unanimously.

This concluded the business.

THE BENEVOLENT FUND.

The Annual Meeting of Donors and Subscribers to the Benevolent Fund was held on Wednesday morning—the chair being occupied by the President.

The minutes of the last annual meeting were taken as read. The minutes of a special meeting which confirmed an alteration of rules were read.

The PRESIDENT, in moving the adoption of the report of the Committee of Management (which was taken as read), said it was his own feeling, and that of the Committee generally, that it was unsatisfactory to find that less than 25 per cent. of the members were subscribers to the fund; the result being that they were unable to consider favourably the whole of the applications received. They had either to cut down considerably the benefits given to deserving cases, or to refuse them altogether. In such an Institution as this, with nearly 900 members, it was an unfortunate circumstance that comparatively so few should subscribe to the fund. He should like to acknowledge the way in which the Affiliated Associations had taken the letter which he had personally addressed to them some time ago, drawing attention to the importance of their assistance in getting members to subscribe. As a consequence of the appeal, the Manchester District Institution gave £10 10s., and did what they could to obtain individual subscriptions; the Eastern Counties Association of Gas Managers had obtained subscriptions to the amount of £3 or £4; the Isle of Wight Association gave a donation of £3 3s.; and the Wales and Monmouthshire Association obtained a considerable number of new subscribers. In this way, their wants for the present were perhaps met; but only for the present. They were able to deal with the cases they had in hand; but they wanted to feel that they had funds enough to enable them to deal fairly and generously with all the cases which came before them. He hoped those present would do what they could, by speaking to their friends, to get them to subscribe, if they did not already do so. He might also mention that, although they did not appeal for subscriptions to anyone outside the Institution, the Committee did not refuse offers of help from any quarter. He had a letter the other day from the proprietors of the "Gas World," asking whether any outsiders would be allowed to subscribe; and the reply to this was that they would be glad to receive a subscription. Consequently, the proprietors of the paper subscribed £2 2s. to the fund.

Mr. J. F. BELL (Derby), in seconding the motion, pointed out that the amount received in subscriptions during the past year was only £143, and the assistance granted amounted to £255; so that, if it had not been for the interest on investments, there would have been a deficiency of over £100. He believed it only required to be known personally to members that they were in need of further funds, and they would be forthcoming. It was a great pity that there were only about 200 subscribers out of 900 members of the Institution; and he appealed, especially to the younger members, to do all they could to increase the number of subscribers.

Mr. H. KENDRICK (Stretford) asked if the list of local Associations mentioned by the President who had assisted during the year was complete. He had been present recently at two District Association meetings—viz., the North of England and the Midland—where the matter had been brought forward.

The PRESIDENT said the explanation was simply that he had given the names of those District Associations who had communicated directly with the Secretary. He knew that other Associations were considering the matter, but had not yet sent in the result.

Mr. KENDRICK further suggested that a reminder should be sent out to the members every year. He thought some dropped their subscriptions simply from forgetfulness.

The PRESIDENT said the Secretary was in the habit of sending out reminders. He feared it was not forgetfulness only which led to dropped subscriptions.

Mr. GEORGE HELPS (Nuneaton) said he was very sorry to find that the Committee were really unable to meet the demands made upon them; but this being the case, he had scrutinized the list of subscribers, and found that there were some 65 subscribers of £1 and over, and 139 of 10s. 6d. and under. It was a good adage to "Look at home;" and it occurred to him to put the question, Were the present subscribers doing all they could to set an example to those who at present stood aloof? They were most of them proud of their positions, proud of their works, and proud of many other things; but he thought there was room for those who were receiving large salaries to show a little more pride in the matter of the Benevolent Fund. If they increased their own subscriptions, they could appeal more effectively to those who did not subscribe. To show that he was in earnest, he was prepared to give £10 at any time when the funds were deficient—not that he could afford it, but he would take the responsibility of collecting it from his friends, who, he had no doubt, would subscribe in that way, if in no other.

The PRESIDENT said that they were much obliged to Mr. Helps for his remarks; but, personally, he felt that it would be far better to get an increase in regular subscriptions from all the members than to get large subscriptions from those who were able to afford it. Still, if anyone else would be good enough to do something on the lines that Mr. Helps suggested, and work among those who had not subscribed hitherto, and get them to do so, it would be a very good thing. It was much better to get a great number of small subscriptions than a few large ones; and if they could only secure an average subscription of 10s. 6d. from all the members, instead of having a total of £140, they would have between £400 and £500, which would probably be sufficient to meet all demands.

The resolution was put and carried unanimously.

The PRESIDENT then announced that the Scrutineers reported that Messrs. Thomas Berridge and Henry Woodall, jun., had been elected to serve on the Committee.

This concluded the business.

COMMUNICATIONS READ.

PUBLIC LIGHTING FROM A MUNICIPAL POINT OF VIEW.

By JACQUES ABADY, M.I.Mech.E., of London.

To the casual observer the question of public lighting appears to be, no doubt, a simple and straightforward matter, involving no more difficulty than placing lamps on columns, lighting them when dusk approaches, and extinguishing them at break of day. As a matter of fact, however, the problem is one of very considerable difficulty because it concerns so many diverging interests. The public, for instance, as it becomes more and more used to improved lighting in dwellings and shops, expects that the lighting of highways will keep pace with such improvements, but does not of course expect to pay more for it. The municipality has to consider the question of cost, and its relation to rateable value; while those supplying the light regard public lighting as something of an advertisement, and naturally enough desire to introduce whatever improvements may be forthcoming from time to time, so that the lighting of the streets may represent the last word in the form of illuminant installed therein. It will, therefore, be seen that there are several separate interests requiring to be reconciled; and I think consideration as to how this can best be done is worth the attention of the Institution of Gas Engineers.

Although from a municipal point of view, the form of illumination would appear to be of secondary importance compared with the volume and distribution of the light itself, yet there is no doubt that the severe competition between gas and electricity almost invariably comes into fierce play when lighting schemes are under consideration. And the relative positions of gas and electricity might perhaps form part of a discussion upon the subject of public lighting. I am, however, free to admit that, given a light of a certain value, distributed in a certain manner, it does not seem of importance to the public whether that light is produced by gas or by electricity; the sole consideration should be the question of relative cost.

It will, therefore, be more profitable to examine the following different forms of street-lighting contracts which are in vogue, and to which members have all at some time or another had their attention very forcibly directed:—

(A). The contract for supply of energy with maintenance, payment being made for so much energy and not for so much light.

(B). The contract for supply of energy only, maintenance being undertaken by a contractor acting for the municipality or the municipal public lighting department itself.

(C). The contract for supply of light, payment being made for so much light irrespective of the energy required to produce it.

What are the relative merits of these forms of contracts (which will be termed Contracts A, B, and C) always assuming them to be equally well drafted in the legal sense, and how do they assure what I venture to point out as desiderata? (which will be termed Points 1, 2, and 3) viz.,

(1). The due observance of the terms of the contract entered into.

(2). The efficient maintenance of the standard of lighting contemplated by both parties when the contract was entered into.

(3). The facility or encouragement for either party to take advantage, during the contract period, of the introduction of improved methods, to either reduce the cost of producing the light, or obtain a greater light for the same cost.

Let me say at once that I look upon a contract as something very difficult to draw up, but comparatively easy to break, in spirit at least; and that it should be borne in mind that it is of the utmost importance that the terms of any contract should establish a mutuality or community of interest—that is to say, it should be to the advantage of both parties to keep to the terms agreed upon. It is one thing for a lawyer to present in triumph to his client a draft contract with a verbal handcuff in every line; but it is quite another matter to look at a question from the point of view of both the contracting parties, and draft an agreement which it is to the personal or pecuniary advantage of both signatories to keep.

Bearing this in mind, and also the desiderata already set out, we may proceed to examine the alternative forms of contract stated under A, B, and C.

CONTRACT A.—*For the supply of and payment by energy—maintenance being undertaken by the contractor for energy.*

Point 1.—The due observance of the terms of this contract naturally hinges upon the facility for measuring the energy supplied. This may be gas or it may be electric current. If the former, it may be agreed to supply through burners with nipples which, tested in the laboratory at a certain pressure, will pass so much gas. To make such a test involves the removal of the burner from the post; and the removal and test of one or a few burners is no guarantee that the bulk are under the same conditions, nor that the pressure under which the burners are tested in the laboratory will be maintained in every street and at every lamp. This can only be ensured by a liberal and constant use of pressure recorders; and the presence of these might easily stop progress in the direction of improved means of gas distribution. If however the contract stipulates a certain consumption by the nipple test, and the maintenance of a certain pressure all over the district, with damages for failure in pressure, it will be seen that by this method a general penalty would be inflicted in respect to many lamps when a failure in pressure is found.

Alternatively, the agreement may involve the use of a governor at each burner; and assuming for a moment the invariability of governors, their introduction is also unsatisfactory because the efficiency of incandescent gas lighting is hampered by limitation of pressure, and therefore the use of increased pressure should be encouraged and not discouraged, as it is by the use of governors. In fact, it is now recognized that just as with an electric lamp the energy is measured by the product of current (amperes) and pressure (volts), so with an incandescent burner the energy is properly measured by the product of current (cubic feet) and pressure (in terms of atmospheric pressure). These two methods of fixing the basis of payment, therefore, seem to fall short of efficiency, and are not to be recommended on this account. The further method of fixing the basis of payment is either by an average-meter system or by tests of consumption *in situ;* and as to these I think the former is unsatisfactory because it naturally induces a tendency to excessive consumption of gas, and does not ensure a community of interest, while the latter, the "*in situ*" method, is one which presents considerable difficulty in carrying it out. When we examine the method of measuring energy as applied to electric current, we find the same unsatisfactory state of affairs. If a lamp is removed and tested in the laboratory, there is firstly no guarantee that the pressure or voltage in the district will be the same as in the laboratory, and there is further in the case of arc lighting no guarantee that the pressure is being effectively applied at the arc itself, or whether, instead, it is being reduced by the lamp mechanism. These remarks dispose, I think, of the first point—viz., the observance of the terms of the contract.

Point 2.—The second point is the efficient maintenance of the standard of lighting under the contract. In the case of a gas-lighting contract, the gas company, be it remembered, is maintaining; and it therefore rests with the company to see that glasses and lanterns are kept clean, that burners are free from dust, and that mantles are replaced when required. So that, assuming *bona fides* and willingness on the part of the company, there is nothing in this form of contract to prevent the standard of lighting being maintained. But looked at from the municipal side of the table, there would be considerable difficulty, in the case of a careless or unwilling gas management, in ensuring that the condition of the public lights shall always be satisfactory. New mantles might be fitted when required; but the quality of the mantles might be poor, and a poor illumination obtained, notwithstanding that the maintenance terms may be adhered to literally. Similarly with an electricity contract. Filament lamps giving a high efficiency, and good carbons might be used if the electricity company so wished. But if not, then inefficient lamps and poor carbons (selected on account of low price) might very conceivably be the cause of a poor illuminating effect, notwithstanding a literal adherence to the terms of the contract.

Point 3.—The third point is an exceedingly important one—viz., what facility or encouragement does this form of contract give to either party to introduce improvements which would reduce the cost of lighting or increase the

light without increase in cost. In this respect I think this form of contract is particularly weak, and will bear a brief examination.

A gas company enters into a contract for a term of years, to supply so many lamps with so much gas per lamp, and maintains the burners. When the contract was entered into, they agreed upon (say) 4 cubic feet per hour, probably at a certain pressure, and contemplated producing thereby a light of (say) 60 candles. All the municipality can demand is the 4 cubic feet per hour. An improved burner is placed upon the market consuming (say) 3 cubic feet of gas, at probably an increased pressure, and yielding (say) 75 candles. Now if the gas company approached the municipality with a proposal to be allowed to substitute the improved burner and pay for the capital cost by the saving in gas to be effected, what is the probable reply of the municipality? Surely in nine cases out of ten it would be that 4 cubic feet is the contract, and that if 3 cubic feet are to be used, a proportionate reduction must be made in the lighting bill. In other words, the municipality would no doubt overlook the fact that improvements in light will probably be effected in the future by a decreased consumption and an increased pressure. Where, therefore, is the incentive to any gas company to reduce its revenue from consumption, and bear the additional capital cost for new burners?

If it is an electricity contract, and we therefore substitute "carbon filament lamps" for "4 feet per hour" and "metallic filament lamps" for "3 feet per hour," is there not a very similar situation created, and would not the same causes operate to prevent improvement, through replacing carbon lamps by metal lamps or carbon arcs by flame arcs? It will be seen that this form of contract is, therefore, against the interests of the public and does not commend itself to the municipal point of view. An example of the stop to progress and improved lighting which follows on this form of contract is to be found in an agreement entered into by the City of Westminster with the Westminster Electric Supply Corporation. It is for supply and maintenance of arc lamps and filament lamps all to consume specified energy at a specified pressure at an inclusive charge per lamp per annum. This contract is, I admit, for a very long period; but this does not affect the point. Open arc lamps, with ordinary carbons and carbon filament lamps, are used; and the consequence is that there is an enormous consumption of current for a poor lighting effect, whereas the substitution of more modern lamps would either enable the same light to be produced for very much less cost or else a vastly improved light to be obtained for the same consumption of current. This example shows clearly how the public interests suffer from a contract of this nature.

CONTRACT B.—*For the supply of and payment by energy, maintenance being undertaken by a separate contractor acting for the municipality, or by the municipal public lighting department itself.*

Point 1.—This form of contract is to a great extent similar to the first form already discussed; and the preceding remarks with regard to the due observance of its terms apply to it.

Point 2.—With regard, however, to the efficient maintenance of the standard of lighting contemplated by the contract, it is on a different footing, for while it is obvious that the municipality (whether it maintains by itself or through a separate contractor) has greater control over efficiency in this respect, yet it will be equally obvious that the interests of the contractor for the energy are very much at the mercy of the municipality. Thus if the maintenance contractor neglects the maintenance, the energy contractor suffers; while if the municipal lighting department (taking as it often does the energy from another municipal department which is in competition with a competitive form of lighting) is interested in doing what it can for its sister department, it is plain that the competitive form of lighting suffers, and real competition is at an end.

It would be affectation to deny that there are many corporations with a municipal gas (or electric) service, a lighting department, and an electricity (or gas) company in competition; and that the outside competitor is denied a fair chance, and on this account the public interest is sacrificed. From my municipal point of view, I hold this to be an unsound position, and I am trying to make clear how this sort of position can arise under the form of contract now being discussed. Where an outside contractor carries out the maintenance, the situation is almost as bad from the energy contractor's point of view, and certainly as bad from the public point of view. An instance of this is Marylebone. Here the gas company undertook to supply gas at so much per thousand. The borough employed a contractor to maintain. Tests which came under my immediate notice showed the efficiency of the gas lighting to be bad—due merely to insufficient attention to burners and lamps. The Council which owns an electricity service was able to put forward a scheme of electric lighting which was obviously better than the results being obtained from the gas lighting; and so the gas company, whose position was prejudiced and whose hands were tied by the state of the gas lighting over which it had no control, lost the public lighting. This is put forward as an example of the weakness to the contractor of this form of contract.

Point 3.—Now when we consider this form with reference to the third point—viz., the facility or encouragement to either party to introduce improvements which would reduce cost or increase the lighting without increase in cost—there is a position strikingly different to that under the first form of contract. Provided the contract does not limit the pressure of the gas supply, the municipality can obviously, if it chooses to pay for them, instal improved burners and give its public a better light, without affecting the contractor's position in the least. What it cannot do, however, is to give the same light by the introduction of improved burners, and reduce the cost of gas or electricity, and so reduce the cost to the public of its lighting bill. Of course, if there were simply an agreement to pay for what total energy is consumed without specifying so much energy per lamp, then such reduction can be made, and the municipality has an absolutely free hand. But then the difficulties of measuring the total energy are very great, and I know of no instance (although there may possibly be some) in which the payment for total energy is made in this way.

An interesting example of the contract in which the company supplies energy, and the municipality maintains, is to be found in the recently executed Calcutta Corporation contract drawn up by my friend, Mr. Alfred Mansfield, as technical adviser to the Corporation, and entered into by that body and the Oriental Gas Company. In the appendix to the present paper are set out the salient clauses in this contract; and those who read them will agree they are drawn in a way which does Mr. Mansfield's thoroughness great credit. I am informed that the contract which this replaces was one for so much light per burner at so much per burner per annum, that this was found to be inelastic because, being for a long period, it set up a standard long since past and at prices now capable of considerable reduction, and that this example shows the weakness of a contract for a certain light at a certain price, which will be dealt with presently.

However that may be, it will be noted that, in order to carry out thoroughly the "B" form of contract, it has been necessary to specify tests of burner nipples, minimum pressure involving forfeiture for default, precautions and safeguards to prevent the Corporation being bound to buy gas at a pressure which may later on be below the generally prevailing minimum which improvements may necessitate, and finally tests of the constituents and quality of gas and its freedom from impurity. It must be pointed out that the Calcutta Corporation are in a position with respect to the Gas Company somewhat analogous to a local authority under the Gas-Works Clauses Act; and on this account the testing clauses are very complete and detailed. But I suggest that even if this were not the position of the Corporation, there is very little which Mr. Mansfield could have omitted if he desired to protect the Municipality as buyers of gas for public lighting from the Gas Company. In other words, it seems that this Calcutta contract carries to its logical extreme the testing arrangements necessary for the public protection if an "A" or "B" contract is entered into with a gas company by a local authority.

There is one matter—purely a statement of my own opinion—which both the "A" and "B" contracts seem not to provide for—that is the question of the decreased quality of gas and increased pressure. "B" contract (as exemplified by the Calcutta agreement) and "A" contract (if it is drafted properly) must specify pressure and quality of gas. Now it seems to me a direction in which future improvements in the efficiency of gas lighting may be found will be in a reduction of the quality of the gas, and an

increase in the pressure at which it is supplied, so that by reducing on the one hand the amount of air theoretically required for perfect combustion, and increasing on the other hand the mechanical means by which that theoretical amount of air is obtained in practice, we shall be enabled to burn the right quality of gas under conditions of absolute maximum efficiency. It will be clearly seen that contracts "A" and "B" specifying as they do either (or both) consumption, pressure, and quality, prevent improvements in the direction suggested.

In connection with contract "B," there is a point of very vital interest to the public which should not be overlooked —that of expense. It is obvious that there are limitations, both by statute and commercial expediency, which govern the price at which it is possible or lawful for electric or gaseous energy to be supplied. At or above this limit, therefore, must such energy be sold to a corporation. There is, however, no limit to what a company (gas or electric) may do in the way of cheap maintenance; and so it will be found, I think, that "Energy + Cost of Maintenance by a Corporation Lighting Department" is, or may be, considerably more expensive than "Energy + Maintenance by the Energy Supplier." On the question of expense, again, where there is a contract "B," there is the possibility of a cheeseparing policy of maintenance being adopted by the municipality, so that for a more or less unimportant annual saving (too often a paper one), the efficiency of the lighting is sacrificed, and the odium falls upon the contractor for energy. The tendency to show savings on estimates is one which the average councillor finds almost irresistible. It would appear to be an ineradicable human weakness.

CONTRACT C.—*For supply of light, payment being made for so much light irrespective of the energy required to produce it.*

Point 1.—The question as to control over the proper fulfilment of this class of contract is one about which there is undoubtedly considerable difference of opinion, and plenty of room for discussion; and, in order that there may be something concrete to discuss, in an appendix are set out the salient clauses of the contract for lighting entered into by the Westminster City Council. The testing clause is one to which attention is particularly directed, because this is the centre of gravity, as it were, of a contract which is for the supply of so much light. I am not personally responsible for the drafting of the clause, and frankly admit there are many alternative methods of framing a clause to a similar effect. I append one hereto as follows:—

> Each lamp is to be fitted with burners, mantles, globes, and fittings, as the case may be, giving a minimum of ——— standard candle power, respectively, as directly measured by the Council's portable photometric apparatus placed at an agreed distance above ground level, and is to burn ——— hours per annum in accordance with a daily schedule to be hereafter supplied by the Council. The fittings and lamp must be in every respect to the satisfaction of the city engineer; and in particular the reflectors above are not to be shaped so as to concentrate the illumination at the foot of the lamps, but horizontally flat or slightly convex or otherwise as may be approved by the city engineer, so as to disperse the rays. The tests will be taken in such a manner as to ensure that the glazing bars shall not interfere with the results obtained.
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> The candle power shall be arrived at by taking the average of two sets of readings in any position with regard to the light under test—one set at an angle of 20° and a second set at an angle of 50° to the horizontal. The photometer used shall be one working on the law of inverse squares, and so constructed as to read accurately whatever the respective colours of the light under test and standard light.
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> Not less than three and not more than six readings, at regular intervals of not less than 30 or more than 60 seconds, shall be made at each angle; and the average of the readings shall be termed the reading or illuminating power at that angle. If, upon a test being made, the illuminating power of any lamp falls below the prescribed standard and is not more than 10 per cent. below it, a test may be made of each of the two nearest lights; and if the aggregate of the light from the three lamps equals the aggregate required by the contract, no damages shall be recoverable. The tests only to be made in reasonably clear weather—not during rain, mist, or fog—and in the presence of a representative of the contractor should he so desire.
>
> The intention of this contract is that the contractor shall assure himself, by continued test and inspection, that the lamps he provides are, during lighting hours, fulfilling in all respects the requirements of this contract; and he shall not claim relief from the conditions of this contract on the grounds of non-notification on the part of the Council of any failure to comply with the terms of this specification.
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> The light given shall be of a steady, invariable character, of a white or yellowish-white colour.

Now the questions that arise on this clause are two. Firstly, does the manner of applying the photometer test ensure an adequate fulfilment of the lighting contract; and, secondly, is the method of making the test itself such as to remove all ambiguity and ground for dispute with respect to any test—in other words, is a photometer test sufficiently definite and certain? On the first of these points it should be observed that the light is determined "as the average of two readings in any position with regard to the light under test, one reading at an angle of 20° and a second reading at an angle of 50° to the horizontal." It will be seen from this that no question of gas or electricity consumption or pressure is involved, but merely a direct photometrical comparison at two definite angles; and the following is the reason why the two angles of 20° and 50° were selected.

It must be recognized that to select any particular angles favouring one form of light would be most unfair. It will also be recognized that to take the mean hemispherical candle power is not practicable, as the comparison involves readings at each angle from 90° to 0°, which is impossible with a test *in situ*, besides being a tedious matter. It will further be recognized by those who have studied street-lighting problems that to include in such a photometrical test either of the angles of 80°, 70°, or 60° would be highly undesirable, because it is at these angles (*i.e.*, in the vicinity of the lamp-post) that one usually gets an excess of light to the detriment of the rays thrown upon the area more distant from the lamp, and their inclusion would encourage, instead of discourage, the distribution of a large volume of light near the post. Now it so happens that if the lighting curves of all types of lamp are examined—electric and gas, arcs, filament, upright and inverted mantles (high and low pressure)—it will be found that in the majority of cases the mean of the light given at 20° and 50° practically coincides with the mean hemispherical intensity, and therefore represents the value as candle power. Of course, it might be possible for an enterprising individual to make a lamp giving (say) 180 candles at 50° and none elsewhere; and this would be a 90-candle lamp. But a lamp such as this would not comply with the general specification of the Westminster testing clause; and the example is here sited simply as a *reductio ad absurdum*.

I emphasize the fact, before leaving this point, that there is no question of the light being defined by a foot-candle test; for one must admit that, had this been done, there would have been introduced all kinds of difficulties and problems (as to the behaviour of light rays with respect to surfaces and view point), about which photometrists themselves are not agreed. The test specified involves simply the light of the lamp itself and the photometer. There is moreover no ground for ambiguity as to the meaning of the contract, because certain candle powers on columns of certain heights are specified throughout. Thus, in the competitive sense, it is a question of price against price for the supply of the same light without any quibble whatever.

The remaining question, then, is whether it is possible to test in such a manner as to remove all grounds for ambiguity and dispute. As a photometrist, I naturally sees no difficulty at all in the matter. But it is possible that those who are not photometrists will look upon a photometer as a very indefinite and indifferent foot-rule indeed; and, of course, it must be admitted that it is necessary to define the kind of instrument and the way it shall be used, in the clearest possible manner. It appears to be quite satisfactory to take an instrument based upon the law of inverse squares, and in which such means of obviating reading errors—due to either colour difficulty or stray light —are provided, as may be agreed upon between the parties entering into the contract. It is also quite simple to agree upon a definite primary standard of light; and it is equally simple to agree upon the secondary standard. This being the case, and it seems that these are all points which are demonstrable, What safeguards against error or chances of dispute should be provided?

I think that these are three—viz., (1) A definition of the weather in which official tests are permissible; (2) absence of infliction of damages if the two lamps nearest to a defective lamp are giving such light as will bring the average of the three up to standard; and (3) the presence of a contractor's representative should be permitted during any test. If one admits the physical possibility of making accurate tests, then what one has to guard against is *mala fides* on the part of the tester, and tests being made under conditions which are beyond the control of the contractor and which might affect the accuracy of the test or the apparent power of the light tested. Surely, if analogy is needed, we only have to turn to the candle power or calorific power or any of the

penal tests now in vogue, and upon which a contractor can be penalized; and we find that just the same conditions will apply. I consider that there is less liability to error in a street test at different angles, because one measurement is involved—viz., a photometer reading; whereas in a quality test, there is liability to error in measurement of the gas, through error in the meter, in the clock, and what not. It must be admitted as a weak point in this form of contract that, because one or a dozen or twenty lamps are tested and found to be giving the specified light, this is no guarantee that several hundred or thousand of lamps will be doing the same thing. On the other hand, there is no limit to the number of lamps which the corporation can test daily if they wish; and further than this a contractor would never know where tests would be made on any night.

Upon the question of the practicability, in working, of such a test clause, it might be pointed out that in Westminster we have already had five years' experience with a gas and electric light contract; and I am not aware of a single dispute, though defects have been found, charged, and paid for. Further, as members will know, invitations were recently issued by the Westminster Council to the Gaslight and Coke Company and to several Electricity Companies, to tender for lighting on this basis, and several offers were received. So certain, apparently, were the Gaslight and Coke Company of the soundness of the basis of the contract and their ability to comply with its terms, that they quoted such prices as have not only ensured to them a continuance of the present gas lighting, but the transfer of several west-end thoroughfares which have been lighted by electricity for some years. And this is after they have had five years' experience of a contract on a photometer basis, made with a Corporation which is most stringent in the carrying out of all its agreements.

If, then, we assume the practicability of the photometrical valuation, how does this contract "C" affect the points 2 and 3?

Point 2.—It is unnecessary to labour the point that this contract ensures—so far as any contract can—"the efficient maintenance of the standard of lighting contemplated by both parties when the contract was entered into." "A" undertakes to supply so much light. "B" undertakes to pay for it if he gets it. He determines whether he gets it by measuring it in a previously agreed manner. It is not necessary to say more as to this. Of course it is obvious that in a contract of this nature, maintenance by the contractor is implied. Otherwise he could not be responsible for the light.

Point 3.—Does this contract facilitate or encourage the adoption by either party of improved methods? It seems to me that it does, because if the contractor finds that he can produce the same light at a cheaper cost, or a better light for the same cost, he would surely approach the corporation and offer to share the benefit of such improvement; and it would be imagined that there are very few municipalities in which the officials or elected members are so neglectful of the public interest as not to take advantage of such an opportunity. As an example of this, an incident occurred only last year when the St. James's and Pall Mall Electric Lighting Company approached the Westminster Corporation with an offer of this kind, which was accepted, and we have been obtaining two or three times the light originally contracted for, without any increase in annual cost. On the other hand, if the municipality wished to adopt (say) a new burner or lamp, consuming the same or less gas or electricity, and costing no more for maintenance, there would surely be no contractor so dead to his own interests (which as was premised are to a great extent publicity or advertising through street lighting) as to refuse such a proposal. A clause to cover such contingencies should properly be inserted in the agreement; and under these circumstances it seems to me that contract "C" is best from a municipal point of view, and best for the contractor as well.

A great deal of the matter put forward does not apply with equal force to cases of a municipal light supply and municipal lighting department; but I suggest that if, as I think has been shown, it is practicable to buy and sell street lighting by light value, then that is the most direct, simple, and generally advantageous course.

Whatever arrangement, however, may exist in a town between suppliers of light and the local authority as to the contractual basis of the public lighting, it is plain that, from a municipal point of view, the selection of suitable units, the proper arrangement of them, and the general distribution of light, are also questions of the utmost importance. And yet, if one may judge from specimens of street lighting, it is evident that these questions are very imperfectly understood; and in place of scientific arrangement of lamps of candle powers suited to the financial ability of a town, one often sees a motley and haphazard positioning of lamps, of all descriptions—exhibiting the crudest and most harmful contrasts of strong glaring light on one spot and next to none on another.

It is unnecessary to dwell upon the fact that what one town can afford in the way of lighting another town cannot. Thus Westminster's lighting bill is £40,000 per annum, and more; but then Westminster has a rateable value of about £6,500,000. If this is contrasted with the rateable value of various towns in England, it will be seen that there are not more than three with over £2,000,000, nor more than twenty over £1,000,000. That is, however, no reason why adequate and scientific light distribution should not be urged upon those responsible for the government of towns, large and small; and therefore a subject well worth discussion is comprised in the question, "What is adequate lighting?"

I am well aware that in many instances—too many instances—the suppliers of light have little or no voice in the selection of positions for lamps or the general drafting of lighting schemes. And it seems to me that this fact makes it all the more important that, by a clear grasp of the principles underlying the scientific arrangement of street-lighting units, they should be in a position to offer criticism to lighting schemes which are open to criticism, and thereby gradually effect an improvement in public lighting on sound and rational lines. I therefore venture to draw attention to some statements of principles and facts, tabulated and collated, bearing upon the distribution of light, even though in so doing I may be travelling over well-worn ground and be laying myself open to the charge of being dogmatic.

Now the first point to be thoroughly grasped is that if one has a lamp of a certain candle power, the distribution of the light in the area affected by such a lamp will vary enormously—getting less and less as one gets more distant from the source of light. This variation in distribution depends on two factors: First the distance from the ground level at which the light is placed; and, secondly, the proportion of light emitted at different angles. If the first is known, the radius in which the light at each angle falls can be easily ascertained; and if the second is known, the actual value of the light when it reaches this radius at ground level can be ascertained just as easily. Light, as is well known, diminishes as the square of the distance from the source, and the distance from the source to the ground at different angles differs greatly with each angle—getting more and more as the angle of depression from the horizontal gets less and less.

A reference to Table I. will provide a concrete example and render the point quite clear. The figures on the left are different heights of the light centre; the figures along the top are different angles of depression from the horizontal. So that the light at 80° is nearer the column than the light at 70°, and so on. The lines (*a*) are distances from the column at which rays at the angles stated will strike the ground. They are arrived at by multiplying the height from the ground to the light by the cotangent of the angle of depression from the horizontal. The lines (*b*) are distances from the centre of the light to the aforesaid points upon the ground. They are arrived at by multiplying the height from the ground to the light by the cosecant of the angle of depression from the horizontal. The lines (*c*) are squares of these last distances.

Taking the first set of figures, for a lamp upon a column 11 feet to centre of light from the ground level. The ray at 80° has to travel 11·17 feet to reach the ground, and if the light were 100 candles, its normal illumination would only be $100 \div (11{\cdot}17)^2$ by the time it reached the ground. In other words $\frac{100}{124}$ foot-candles. But the ray at 10° has to travel 63·36 feet to reach the ground, and if the light were 100 candles, its normal illumination would only be $100 \div (63{\cdot}36)^2$ by the time it reached the ground. In other words $\frac{100}{4014}$ foot-candles or only $\frac{1}{32}$nd of the 80° ray. It will be seen, therefore, that, given a certain candle power, the normal illumination decreases in the proportion or ratio of the squares of the distances for the various angles; and taking 80° as 1, these ratios progress until 32 is reached

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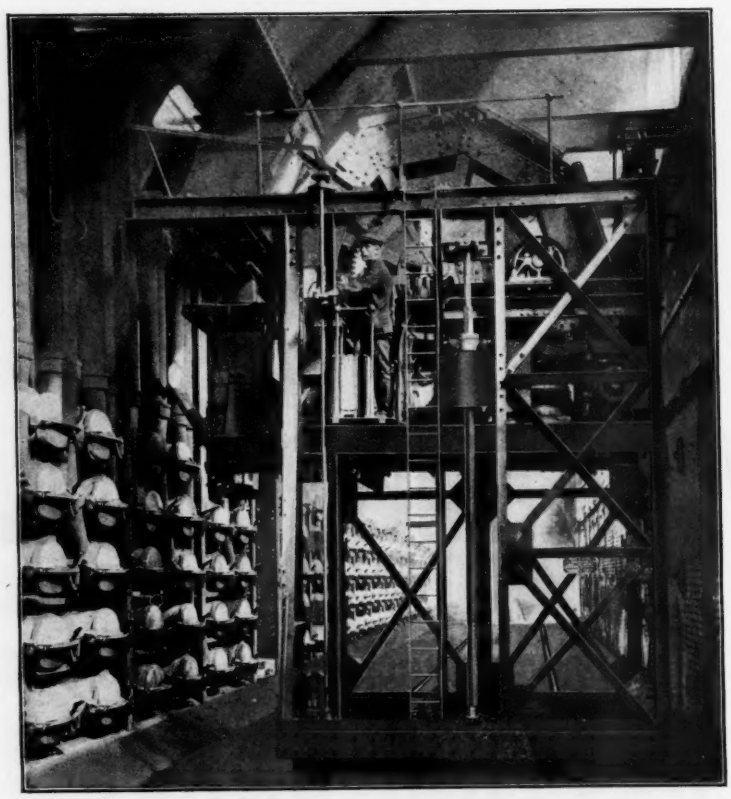

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Greatly reduces the cost of Carbonization.
Works without any injury to the Retorts.
Has discharged and charged 24 Retorts in 19½ Minutes.
Retort Lids being open a very short time, practically no Heat or Gas is wasted.
Charges can be packed if desired.
Requires no Water for cooling.
Makes no Dust, Noise, or Flame.
Takes supply of Coal Automatically from Overhead Hopper, without stopping, or can be fitted with Self-Contained Hopper.
Does not break down.
Reduces maintenance charges to a minimum.

References to many Gas-Works at Home and Abroad.

Telegrams: "MOTORPATHY, LONDON."
Telephone: 5118 WESTMINSTER.

Avonbank Works, BATH.
Telegrams: "SIMULTANE, BATH."
Telephone: 536 BATH.

Full Particulars from—

ALDRIDGE & RANKEN,
39, VICTORIA STREET,
LONDON, S.W.

TABLE I.

Angle of Depression from Horizontal.

Height of Light from Ground.		80°	70°	60°	50°	40°	30°	20°	15°	10°
11 feet .	(a) . .	1·9	4·0	6 35	9·3	13·1	19·0	30·2	41·0	62·37
	(b) . .	11·17	11·7	12·7	14·35	17·1	22·0	32·15	42·46	63·36
	(c) . .	124	136	161	206	292	484	1033	1802	4014
12 feet .	(a) . .	2·1	4·37	6 92	10·0	14·3	20·75	33·0	44·8	68·0
	(b) . .	12·184	12·76	13 84	15·66	18·66	24 0	35·0	46·3	69·1
	(c) . .	148	162	191	245	348	576	1227	2145	4777
13 ft. 6 in.	(a) . .	2·36	4·9	7·79	11·3	16·0	23·35	37·0	50·4	76 5
	(b) . .	13·7	14·36	15·58	17·61	21·0	27·0	39·5	52·1	77·8
	(c) . .	187	206	242	310	441	729	1557	2715	6046
15 feet .	(a) . .	2·64	5·46	8·65	12·58	17·85	25·9	41·2	56·0	85·0
	(b) . .	15·23	16·0	17·3	19·57	23·3	30·0	43·8	58·0	86·4
	(c) . .	232	256	299	383	544	900	1921	3352	7465
20 feet .	(a) . .	3·52	7 28	11·54	16·78	23·8	34·6	55·0	74·6	113·4
	(b) . .	20·3	21·28	23·0	26·0	31·1	40·0	58·46	77·2	115·2
	(c) . .	412	452	532	681	967	1600	3417	5960	13,225
25 feet .	(a) . .	4·4	9·1	14·4	21·0	29·7	43·25	68·7	93·3	141·75
	(b) . .	25·4	26·6	28·8	32·6	38·8	50·0	73·0	96·5	144·0
	(c) . .	644	707	832	1064	1511	2500	5339	9312	20,736
Ratio of (c) 80° = 1		1	1·1	1·28	1·64	2·34	3·88	8·27	14·4	32·2

TABLE OF MEASUREMENTS AT VARIOUS ANGLES.

(a) = distance from column
(b) = distance from light centre to the ground } All distances are in feet and decimals.
(c) = the square of (b)

TABLE II.

Feet from Ground . . . (proposed new column)	11·0	12·0	13 6	15·0	20·0	25·0
Feet from Ground (existing column).						
11·0	.. ..	1·2 *1·07*	1·5 *1·21*	1·8 *1·33*	3·3 *1·78*	5·0 *2·24*
12·0	·8 *·93*	.. ..	1·26 *1·13*	1·6 *1·24*	2 8 *1·66*	4·3 *2·09*
13·6	·66 *·82*	·8 *·88*	.. ..	1·23 *1·1*	2·2 *1·47*	3·4 *1·84*
15·0	·54 *·75*	·64 *·8*	·8 *·91*	.. ..	1·8 *1·34*	2·8 *1·67*
20·0	·3 *·56*	·36 *·6*	·45 *·68*	·56 *·74*	.. ..	1·5 *1·25*
25·0	·2 *·445*	·23 *·48*	·3 *·54*	·36 *·6*	·64 *·8*	.. ..

NOTE.—The top row of figures shows the ratio of increased light required to yield the same illumination of ground area if one height of light centre is substituted for another.
The figures in italics show the increased length of road which will be illuminated if one height of light centre is substituted for another. The proportion varies somewhat with "hit and miss" lighting, as the road widths vary, and the above figures are therefore approximate.

at the 10° angle. These ratios are always the same, and are set out at the foot of Table I.

What is to be gathered from the above facts? Surely this: That if street-lamps are so placed in the streets that the 10° ray of one lamp meets the 10° ray of the next, then one will be relying for the lighting of each area upon the unaided illumination of a single lamp, and the illumination on a line between the lamps will decrease in the proportion of 1 : 32 (with portions of the street having even less illumination) unless it can be corrected by either providing lamps with a distribution at each angle which will remedy this disproportion, or else by altering the relative positions of the lamps. This point should be clearly understood, for it is universal in its application to all heights, types, and forms of light.

Looking now at the 12 ft. light, it will be seen that here the proportions are just the same as before; but because the lamp is higher the squares of the distances to the ground are greater, but the area covered (which is reckoned as length of street) is larger. It follows from this that given a light of a certain candle power upon a certain height of column, if it is required to place it upon a higher column in order to illuminate a larger area, the light itself must be increased in candle power if the same illumination is required.

In Table II. are set out these two relative properties. In it, the top row of figures shows the ratio of increased light required to yield the same normal illumination of ground area if one height of column is substituted for another, while the second row of figures shows the relative areas illuminated by lights of various heights. Thus, supposing it is required to replace 11 ft. columns by 20 ft. columns, and get the same normal illumination, the candle power must be increased 3·3 times, but the area or length of street illuminated will be 1·78 times as large. That is to say, if there are 17·8 100-candle power lamps 100 feet apart in a road 1780 feet long, one would require 10 330-candle power lamps 178 feet apart to yield the same light. It will be gathered from this that, unless the relative cost of providing a 330-candle power lamp is less than is the ratio of 3·3 : 1·78, it would not be a paying proposition to make the substitution suggested in the example.

The overlooking of this simple rule is the cause of much mystification of councillors, and much harm to public lighting. If it is overlooked, it might be said 20 1800-candle power lights which equal 36,000 candles (neglecting the rule referred to) will give twice as good normal illumination as 200 90-candle power lights which equal 18,000 candles (neglecting the rule referred to); and yet, of course, such a comparison would be totally fallacious. But is not this sort of comparison made very often, and is it not only by a clear grasp of this question of relative distribution that one can deal with such fallacious comparisons? As a matter of fact, it is only when considering lights with reference to the same height from the ground that the candle power shows the true proportion of increase. Thus, 200 candles on a 15 ft. column is twice 100 candles on a 15 ft. column, but is not twice 100 candles on an 11 ft. column.

Before dealing with the part of the subject which I approach with some diffidence—viz., the proper spacing of lamps—I wish to make three points clear. Firstly, I reckon the distances in feet on a line parallel with the kerb to the nearest lamp, whether considering central lighting or whether the lamps are placed in hit-and-miss fashion. That is to say in the latter case 70 feet will mean 70 feet (not diagonally) to the next lamp on the opposite side of the carriage way. Secondly, all such distances are approximate only, because naturally they will vary as the width of the carriage way varies. Thirdly, in considering the candle power on the ground surface, I simply divide the candle power at the angle by the square of the distance, and do not multiply by the sine of the angle of depression (equivalent to the cosine of the angle which the rays make with the normal to the illuminated surface). Had this course been followed, it would have been introducing something problematical, because the propriety of the application of the cosine law is affected not only by the angle of incidence, but also by the angle at which the illuminated spot is viewed, by the nature or condition of the surface, and so on. I would point out, however, that had I multiplied by the sine of the angle of depression, I would be multiplying the disproportion of the lighting enormously, and making my point stronger; so that this multiplication is not omitted from any motive of "special pleading." Moreover, the object of street lighting is not only to illuminate the flat ground surface to which the sine multiplication only applies but also objects lying upon it and vertical moving figures as well. The figures given, therefore, are all comparative, and are literally true in terms of an imaginary surface receiving normal illumination.

If it is desired to express them in terms of illumination upon a horizontal or a vertical surface, they should be multiplied by the sine and the cosine respectively of the angle of depression of the rays from the horizontal.

Now, by consulting Table I. it will be seen that as between 80° (near the column) and 10° (away from the column) the illumination will decrease to $\frac{1}{32}$nd. If, therefore, one does not desire greater unevenness of illumination than 1 to 32 (surely an enormous variation) one must place the lamps at a distance apart equal to twice the radius of the 10° angle,

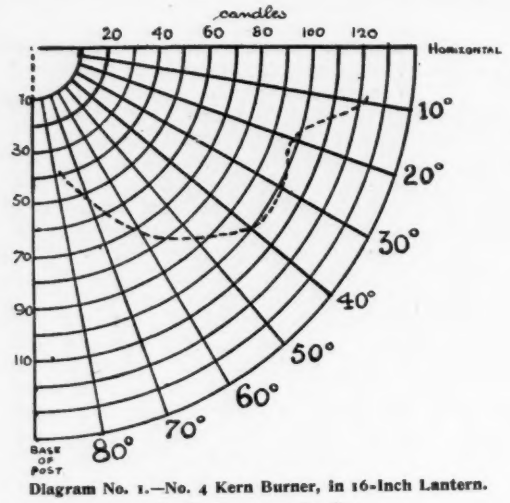

Diagram No. 1.—No. 4 Kern Burner, in 16-Inch Lantern.
Candle Power: 93 Candles.

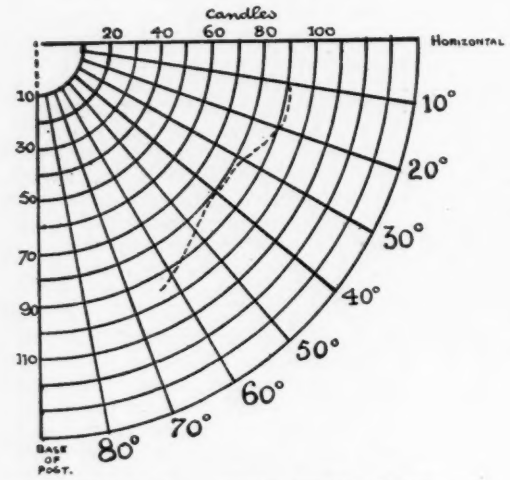

Diagram No. 2.—Inverted Burner in Lantern.
Candle Power: 86 Candles.

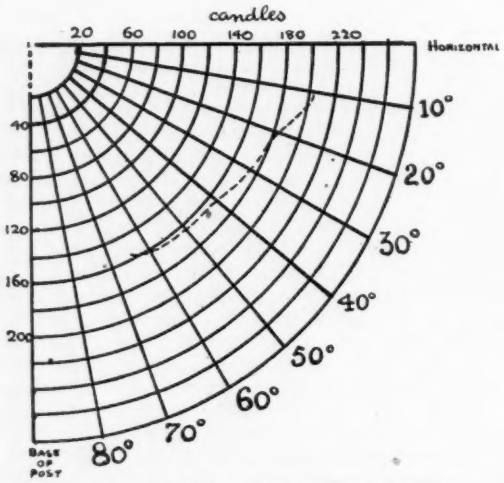

Diagram No. 3.—Two Inverted Burners in Lantern.
Candle Power: 174 Candles.

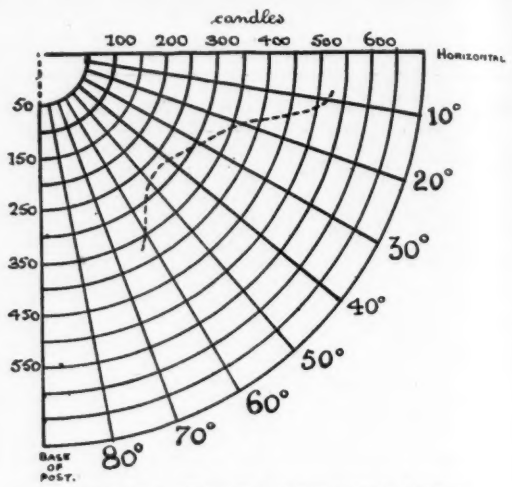

Diagram No. 4.—Three Inverted Burners in Lantern.
Candle Power: 319 Candles.

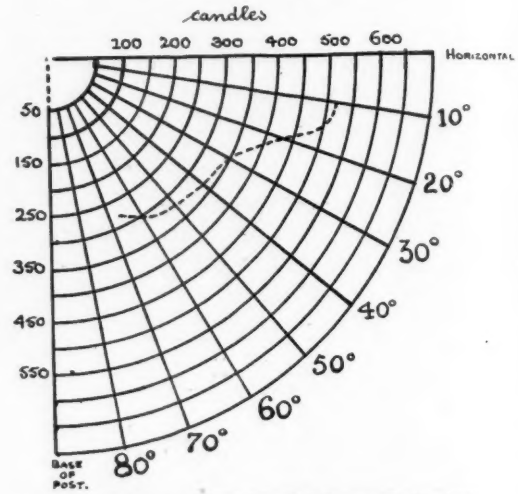

Diagram No. 5.—Three Inverted Burners in Lantern.
Candle Power: 368 Candles.

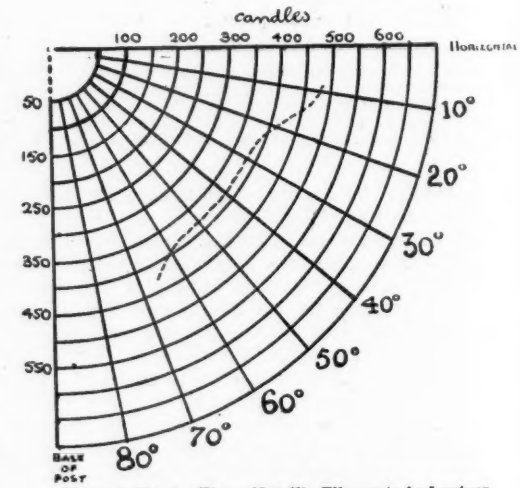

Diagram No. 6.—Three Metallic Filaments in Lantern.
Candle Power: 387 Candles.

so that the 10° ray of one lamp meets the 10° ray of the next. These approximate distances for various heights of light are as follows:—

Height of Light.	10° Meeting 10°.
11 ft.	125 feet
12 ,,	136 ,,
13 ,, 6 in.	153 ,,
15 ,,	170 ,,
20 ,,	227 ,,
25 ,,	284 ,,

A variation of from 1 to 32 cannot be considered a satisfactory one; and it is a mistake to think that, in order to make the light stronger at the distant points, all that is needed is to increase the candle power of the source. Naturally, this does increase the light at the distant points; but it also increases the light round the column in the same proportion, and if carried to its extreme (as it often is), this course only results in a very glare of light round the column, which glare, by reason of the contrasts it introduces, makes the disproportion apparently worse. Everyone knows the effect of going out of the sun light into a darkened room—how at first one cannot see at all, and how after the eye has lost the effect of the sun's glare, the vision accommodates itself to the feeble light of the dim room.

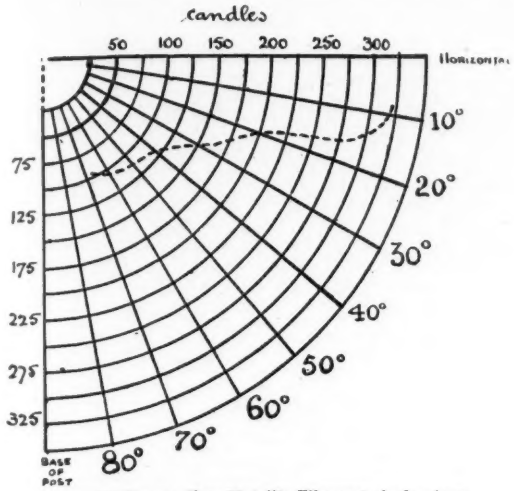

Diagram No. 7.—Two Metallic Filaments in Lantern.
Candle Power: 161 Candles.

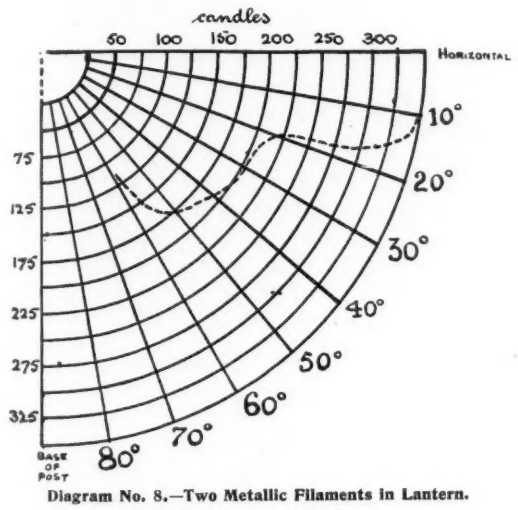

Diagram No. 8.—Two Metallic Filaments in Lantern.
Candle Power: 201 Candles.

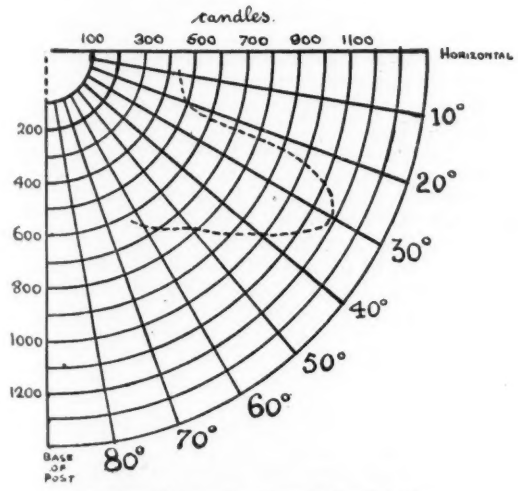

Diagram No. 9.—Five-Ampere Enclosed Arc.
Candle Power: 616 Candles.

That is just the effect which the eye encounters in walking along a street lighted in this manner; and it is astonishing that this practice is followed to the extent that it is.

Reverting to the list set out above, if they are compared with the distances at which lamps are actually placed, it will be found that in many cases the distances are far greater, and that there are small areas of over-bright light and larger patches with practically none at all. Thus, through want of a little thought and the application of simple rules, street lighting in many cases degenerates into a haphazard scheme of point lighting, instead of being, as it should be, the even and uniform distribution of artificial light.

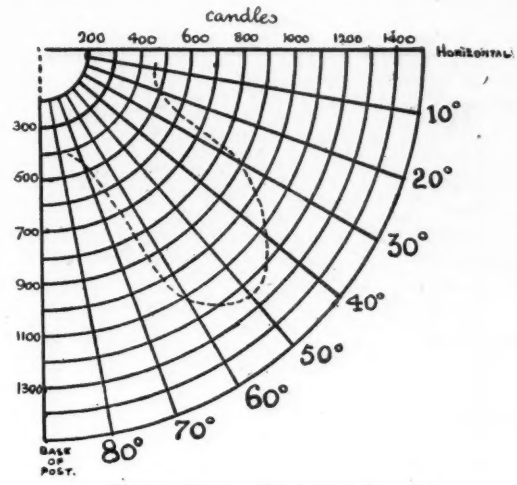

Diagram No. 10.—Ten-Ampere Open Arc.
Candle Power: 1000 Candles.

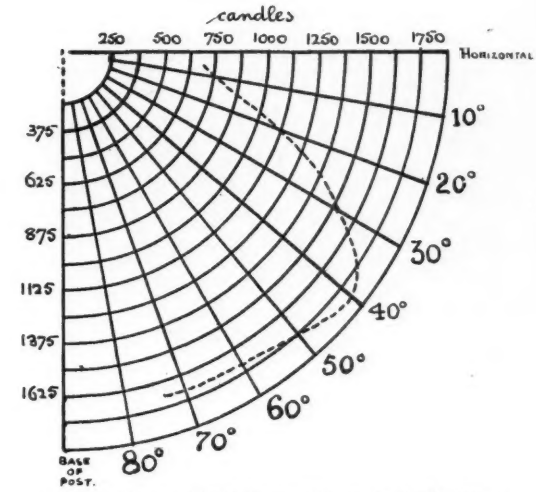

Diagram No. 11.—Eight-Ampere Flame Arc (Old Pattern).
Candle Power: 1435 Candles.

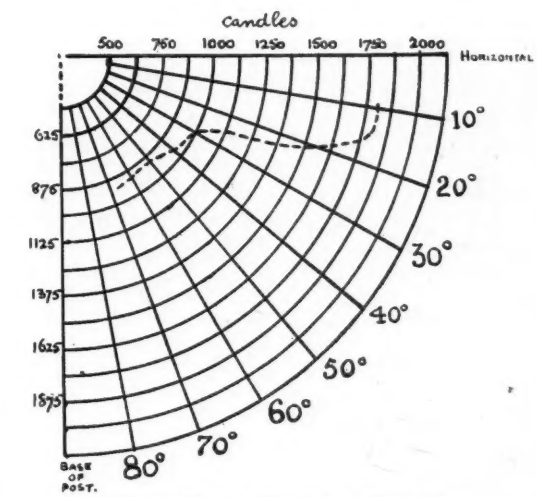

Diagram No. 12.—Ten-Ampere Flame Arc.
Candle Power: 1326 Candles.

The more attention is drawn to it, the more will this disproportion of light diffusion and the unevenness of distribution probably be noticed, and it is hoped in course of time remedied. The question is, what can be done to improve this state of things, even though the standard set up for attainment is an ideal one? It appears to me that there are two ways. The first way is to select lamps with lighting curves which are greater at 10° than at 15°, greater at 15° than at 20°, and which get less and less as they approach the 80° angle. To do this involves the use of dioptric arrangements or reflectors, and, of course, the disproportion can at best only be partially remedied.

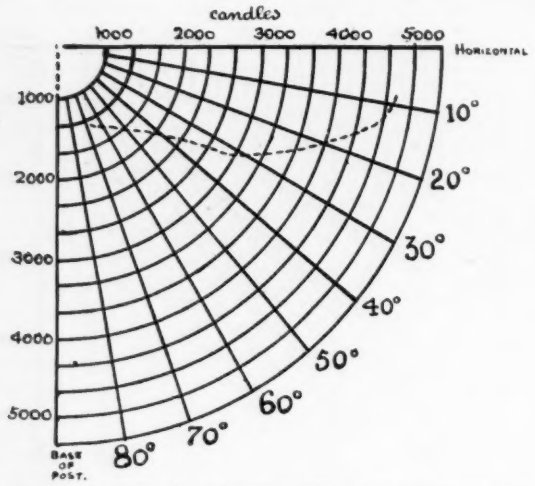

Diagram No. 13.—"Excello," 660-Watt, Flame Arc, with Dioptric Globe.
Candle Power: 2812 Candles.

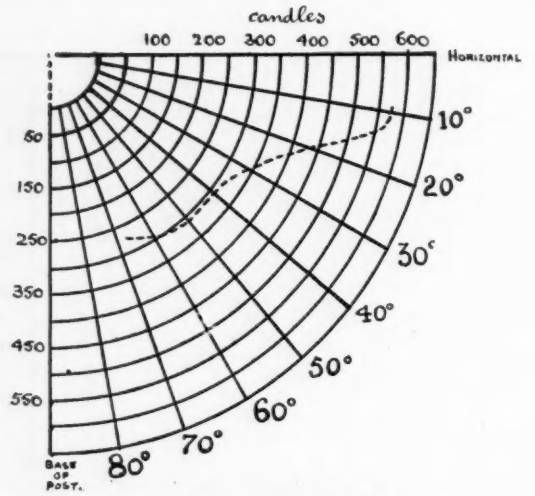

Diagram No. 14.—Open Arc, 500-Watt.
Candle Power: 363 Candles.

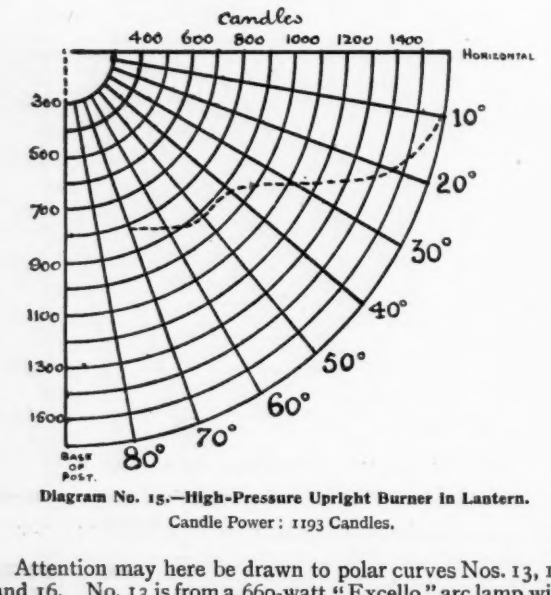

Diagram No. 15.—High-Pressure Upright Burner in Lantern.
Candle Power: 1193 Candles.

Attention may here be drawn to polar curves Nos. 13, 15, and 16. No. 13 is from a 660-watt "Excello" arc lamp with dioptric globe; and it will be seen that this is entirely in the right direction, and that the light gets less and less as one approaches the angle nearest the column. No. 15 is from a high-pressure vertical incandescent burner; and No. 16 from a high-pressure 3000-candle power triple inverted burner. It will be seen that here also the lighting curve is in the right direction, but not to the same extent as the "Excello" lamp. They show what can be done by makers of electric and gas lamps if the necessity to do it is grasped and insisted

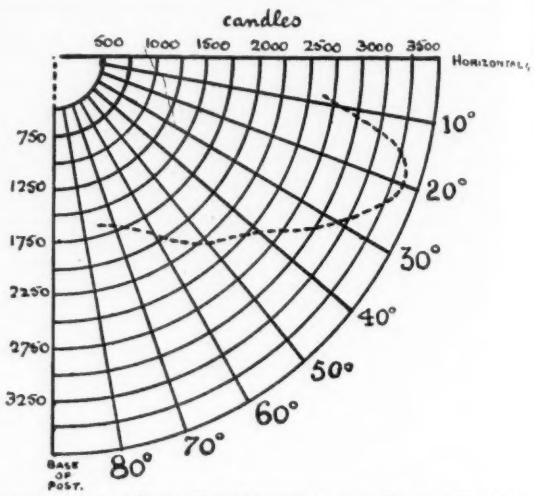

Diagram No. 16.—Three High-Pressure Inverted Burners in Lantern.
Candle Power: 2965 Candles.

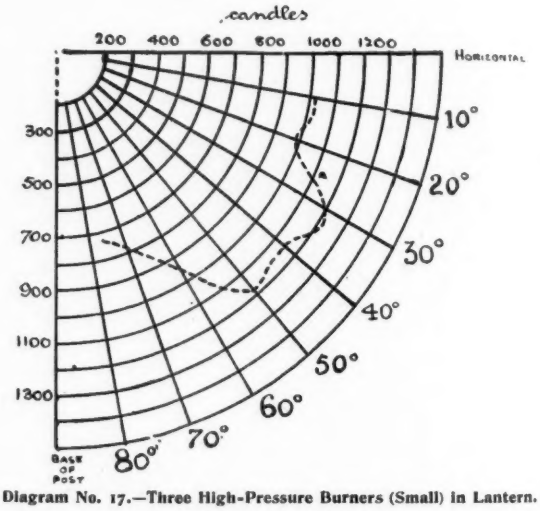

Diagram No. 17.—Three High-Pressure Burners (Small) in Lantern.
Candle Power: 960 Candles.

upon; and they contrast signally with the light curves of some of the other specimens, which comprise all types of light and are the diagrammatic representation of figures obtained, not from makers' but from independent tests. A bad example is curve No. 11—a flame arc without dioptric globe. That is the sort of thing which would give a mass of brilliant, dazzling, glaring light near the column and comparatively little in the midway position. A bad example of a gas lamp is No. 2—an inverted burner in lantern. Here the maker has evidently tried to get even distribution of candle power *per se* and very well he has succeeded. But in the light of Table I. it will be seen how unsuitable for public lighting this is. Perhaps when one says that an even polar curve is unsuitable for public light one ought to limit the application of this criticism and add "if each area is to be illuminated by the practically unaided light of a single lamp."

And this brings one to consider the second way in which evenness of illumination can be procured—perhaps a costly method, but certainly a most effective one. In Table III. there is set out the foot-candle illumination given by the lamps of which the polar curves are appended, and it will be seen that they all diminish towards the 10° ray. Failing, therefore, the possibility of making lamps with such a polar curve as will compensate for this disproportionate distribution curve, it appears that the only method of producing anything approaching even lighting is to bring the lighting units closer together, and that it is no remedy to increase the power of the units on each column. For if this is done, while it increases the light generally, it utterly fails to alter the relative distribution; and, indeed, by inducing a glaring effect at each column, it only serves to increase the contrast and make the lighting effect worse. It is obvious then, that if one brings the columns closer together, the lighting effect at its weakest point will be reinforced and the unevenness of the distribution diminished. It will also be possible to reduce the candle power of the sources of light, because there

TABLE III.

No. of Lamp Diagram.	Height to Centre of Light in Feet.	Distance in Feet Between Lamps.	Foot-Candle Normal Illumination at Angles of Depression Specified.													Ratio of Greatest to Least Light.
			60	50	40	30	20	15	10	15	20	30	40	50	60	
1 . .	11	125	·46	·427	·34	·21	·095	·06	·03	·06	·095	·21	·34	·427	·46	15
2 . .	12	136	·47	·34	·23	·14	·07	·04	·019	·04	·07	·14	·23	·34	·47	24
3 . .	13·6	153	·8	·53	·38	·24	·11	·08	·033	·08	·11	·24	·38	·53	·8	24
4 . .	15	170	1·18	·73	·52	·35	·19	·13	·07	·13	·19	·35	·52	·73	1·18	17
5 . .	15	170	1·0	·86	·6	·38	·21	·15	·07	·15	·21	·38	·6	·86	1·0	14
6 . .	15	170	1·3	·9	·7	·42	·21	·15	·06	·15	·21	·42	·7	·9	1·3	21
7 . .	15	170	·38	·35	·25	·17	·1	·08	·044	·08	·1	·17	·25	·35	·38	8
8 . .	15	170	·43	·46	·36	·24	·11	·09	·046	·09	·11	·24	·36	·46	·43	10
9 . .	20	227	1·27	1·1	1·0	·73	·13	·07	·033	·07	·13	·73	1·0	1·1	1·27	38
10 . .	20	227	·8	1·6	1·3	·7	·26	·1	·034	·1	·26	·7	1·3	1·6	·8	47
11 . .	20	227	3·2	2·8	2·0	1·0	·32	·16	·056	·16	·32	1·0	2·0	2·8	3·2	57
12 . .	20	227	1·7	1·3	1·0	·62	·46	·31	·136	·31	·46	·62	1·0	1·3	1·7	12
13 . .	25	284	1·8	1·55	1·37	1·21	·74	·46	·23	·46	·74	1·21	1·37	1·55	1·8	8
14 . .	20	227	·56	·46	·33	·215	·11	·08	·043	·08	·11	·215	·33	·46	·56	13
15 . .	20	227	1·6	1·37	·96	·7	·42	·25	·12	·25	·42	·7	·96	1·37	1·6	13
16 . .	25	284	2·3	2·2	1·7	1·26	·65	·34	·134	·34	·65	1·26	1·7	2·2	2·3	17
16 . .	20	227	3·6	3·4	2·8	2·0	1·0	·53	·21	·53	1·0	2·0	2·8	3·4	3·6	17
17 . .	20	227	1·8	1·6	1·5	·75	·28	·16	·075	·16	·28	·75	1·5	1·6	1·8	24

NOTE.—The ratios of the greatest to the least light show how the illumination varies. Ideal ratio = 1.

TABLE IV.

No. of Lamp Diagram.	Height to Centre of Light in Feet.	Distance in Feet Between Lamps.	Foot-Candle Normal Illumination at Angles of Depression Specified.									Ratio of Greatest to Least Light.
			60 10	50 10	40 10	30 15	20 20	15 30	10 40	10 50	10 60	
1	11	60	·49	·43	·37	·27	·190	·27	·37	·43	·49	2·6
2	12	66	·489	·359	·249	·28	·14	·28	·249	·359	·489	3·5
3	13·6	74	·833	·563	·413	·32	·22	·32	·413	·563	·833	3·8
4	15	82	1·25	·8	·59	·48	·38	·48	·59	·8	1·25	3·3
5	15	82	1·07	·93	·67	·53	·42	·53	·67	·93	1·07	2·5
6	15	82	1·36	·96	·76	·57	·42	·57	·76	·96	1·36	3·2
7	15	82	·424	·394	·294	·25	·2	·25	·294	·394	·424	2·1
8	15	82	·476	·506	·406	·33	·22	·33	·406	·506	·476	2·3
9	20	110	1·30	1·13	1·03	·8	·26	·8	1·03	1·13	1·30	5·0
10	20	110	·834	1·63	1·33	·8	·52	·8	1·33	1·63	·834	3·1
11	20	110	3·25	2·85	2·05	1·16	·64	1·16	2·05	2·85	3·25	5·0
12	20	110	1·83	1·43	1·13	·93	·92	·93	1·13	1·43	1·83	2·0
13	25	138	2·03	1·78	1·6	1·67	1·48	1·67	1·6	1·78	2·03	1·3
14	20	110	·603	·503	·373	·295	·22	·295	·373	·503	·603	2·7
15	20	110	1·72	1·49	1·08	·95	·84	·95	1·08	1·49	1·72	2·0
16	25	138	2·43	2·33	1·83	1·6	1·3	1·6	1·83	2·33	2·43	1·9
16	20	110	3·81	3·61	2·81	2·53	2·0	2·53	2·81	3·61	3·81	1·9
17	20	110	1·87	1·67	1·57	·91	·56	·91	1·57	1·67	1·87	3·3

NOTE.—The ratios of the greatest to the least light show the great improvement compared to those produced by the arrangement of which the effect is tabulated in Table III.

is always an excess of light near the column on account of the initial candle power necessary to give enough light at the distant points. I, therefore, urge attention to this view—viz., the desirability of decreasing the initial candle power of light units and placing them closer together.

I am well aware that cost enters largely into the question of street lighting, and with this in mind suggest that it is better lighting to give a comparatively feeble but even illumination than it is to give a more powerful illumination full of contrasts between the light near the columns and that towards the midway position between them. I find that a suitable arrangement (though possibly not an ideal one) of what might be termed "overlapped" lighting, is to plot the positions so that the 20° angle of one lamp meets the 20° angle of the next.

A moment's thought will make it evident that to do this involves placing the lamps very close together; but it will also be evident from a glance at Table IV., in which the effects from the lamps instanced in Table III. when so placed are shown, that the disproportion of the lighting effect is very much less in most cases—the worst examples being those lamps having a relatively small illuminating power at the distant angles. Now if this method sets up an unattainable ideal on account of cost, at any rate it sets up something to approach if not to attain, and indeed if the question of a suitable polar curve (greater light at 10°, 15°, and 20° than at the nearer points) is also considered and properly-made lamps are insisted upon, then it is not necessary to do more than to arrange the distances so that the 15° ray of one approximately overlaps the 20° ray of the next, or even overlaps the 15° only.

Applying these methods to the Curves Nos. 13 and 16, we arrive at the following effects:—

	60°	50° 10°	40° 10°	30° 10°	20° 15°	15° 20°	10° 30°	10° 40°	10° 50°	60°
No. 13 . .	1·8	1·78	1·60	1·44	1·2	1·2	1·44	1·60	1·78	1·8
No. 16 . .	2·3	2·33	1·83	1·39	·99	·99	1·39	1·83	2·33	2·3

	60°	50°	40°	30° 10°	20° 10°	15° 15°	10° 20°	10° 30°	40°	50°	60°
No. 13 .	1·8	1·55	1·37	1·44	·97	·92	·97	1·44	1·37	1·55	1·8
No. 16 .	2·3	2·2	1·7	1·39	·78	·68	·78	1·39	1·7	2·2	2·3

Assuming, then, that either of these three arrangements is possible, or perhaps it would be better to say attainable, the distances are as follows, and in setting them out the distances for the first arrangement of lamps with practically no effective overlapping are repeated by way of contrast:—

Height of Light.	10° Meeting 10°.	15° Meeting 15°.	15° Meeting 20°.	20° Meeting 20°.
11 ft. ..	125 ft. ..	82 ft. ..	72 ft. ..	60 ft.
12 ,, ..	136 ,, ..	90 ,, ..	78 ,, ..	66 ,,
13 ft. 6 in...	153 ,, ..	101 ,, ..	88 ,, ..	74 ,,
15 ft. ..	170 ,, ..	112 ,, ..	98 ,, ..	82 ,,
20 ,, ..	227 ,, ..	150 ,, ..	130 ,, ..	110 ,,
25 ,, ..	284 ,, ..	187 ,, ..	162 ,, ..	138 ,,

It is very difficult indeed to lay down any standard of lighting, and to say what lighting is suitable for a particular street. In all cases, naturally, positions have to be varied to coincide with street corners and to give greater light at crossings, &c., while the demands of a business street with heavy traffic will naturally not be the same as those of a residential street. Nor even if the demand were made or put forward in competition would the same type of light suit all streets. Thus, high unit lights on tall columns would be most unsuitable for a residential street, because the direct light produced at the level of bedroom windows is not to be desired. All one can do is to point out what effect, with respect to evenness of distribution, will be produced by various combinations of heights and distances. In case it will be of any guidance I give some approximate particulars of some streets in Westminster; but in looking at these members should bear in mind that when the new scheme of lighting is completed at the end of the year, the City of Westminster will be lighted by the following units spaced as regard heights and distances as nearly coincident with the figures given above having regard to the character and needs of each individual street:—

Units now Adopted by Westminster City.

12 ft. for 90 candles; 12 ft. for 180 candles; 15 ft. for 300 candles; 20 ft. by 1800 candles; 20 ft. for 3000 candles.

Some Examples of Existing Lighting in Westminster.

Street.	Description.	Height of Light. (Approximate)	Distance Apart. (Approximate)	Approximate Arrangement.
Atterbury Street . .	60 c.p. Incandescent	12 ft.	130 ft.	10° meets 10°
Berwick Street . .	100 ,, ,,	12 ,,	80 ,,	15° ,, 20°
Bond Street . . .	500 ,, Open arc	20 ,,	140 ,,	15° ,, 15°
Bow Street . . .	100 ,, Incandescent	12 ,,	55 ,,	20° ,, 20°
Kensington—				
(Main Road). .	60 ,, ,,	12 ,,	60 ,,	20° ,, 20°
Palace Street . . .	60 ,, ,,	12 ,,	90 ,,	15° ,, 15°
Princes Gate . . .	60 ,, ,,	12 ,,	45 ,,	20° ,, 30°
Regent Street. . .	3000 ,, Flame arc	23 ,,	170 ,,	15° ,, 15°
Sackville Street . .	100 ,, Incandescent	12 ,,	80 ,,	15° ,, 20°
St. George's Road .	500 ,, Open arc	20 ,,	150 ,,	15° ,, 15°
St. James's Street .	900 ,, Arc	20 ,,	145 ,,	15° ,, 15°
Shaftesbury Avenue .	100 ,, Incandescent	11 ,,	45 ,,	20° ,, 30°
Tachbrook Street .	500 ,, Arc	20 ,,	150 ,,	15° ,, 15°
Tothill Street . . .	60 ,, Incandescent	12 ,,	45 ,,	20° ,, 30°

I fear that I have dealt with the subject at some length and with a discursiveness which it has been a difficult matter to try to avoid, and can only conclude by expressing the hope that some at least of my remarks may be of service in helping forward the movement for the improvement on rational lines of street lighting.

APPENDIX I.

Extract from the Calcutta Corporation Street Lighting Contract.

3. The said Company agree, in respect of all lamps fixed after the 1st of May, 1911, at their own expense, to supply, fix, and maintain all the necessary piping, both below and above ground, to convey an ample supply of gas, at the agreed pressures, to each and every public light in Calcutta, together with a brass cock of a design to be approved by the said Corporation. The said brass cock will be screwed by the said Company to the end of each pipe at each public light, at such a height and in such a position as may be directed by the said Corporation, in order that the burners belonging to the said Corporation may be readily and securely attached.

4. The said Corporation undertake at their own expense to supply, fix, and maintain all lamp posts, brackets, lanterns, burners, and mantles used in connection with the public lights of Calcutta, all of which shall remain the property of the said Corporation, and the said Corporation shall also at their own expense undertake the lighting and extinguishing of all public lights.

5. In accordance with the terms of this agreement the said Company shall supply gas only, and will be paid by the said Corporation at a fixed rate per 1000 cubic feet delivered in such manner, in such places, and in such quantities as provided in the various clauses of this agreement.

6. The period over which this agreement shall extend is twenty years, commencing on the 1st day of May, 1911.

In agreeing to such a lengthened period, the said Corporation have been influenced by the fact that it will be necessary for the said Company to spend considerable sums of money to bring their plant and piping to the state of efficiency required by the provisions of this agreement, and it is reasonable that such large expenditure should be spread over a lengthened period.

7. The said Company shall for a period of twenty years from the 1st of May, 1911, have the exclusive right of supplying with gas all such public street-lamps as during that period may be lighted with gas throughout any part of Calcutta, or other districts, or places, which now are, or hereafter may be, under the jurisdiction or control of the said Corporation of Calcutta, or their successors, subject always to the faithful fulfilment of the terms of this agreement.

8. The said Company shall only manufacture and supply gas which is the product of the distillation of coal, commonly known as coal gas, and the said Company shall neither dilute nor enrich this gas with any other agent, gas or vapour, without first obtaining the consent of the said Corporation in writing.

9. The said Company shall cause to be provided, at their own expense, before the 1st day of May, 1911, in any part of Calcutta selected by them, a testing place, or places, with suitable apparatus therein for testing the illuminating power, purity, and pressure of the gas supplied, and the said Company shall at all times thereafter keep and maintain such testing places and apparatus in good repair and working order, and the result of any testings or examinations made in such testing place, or places, belonging to the said Company shall be receivable in evidence.

10. The said Corporation may, if they think fit, on each occasion of the testing at any testing place of the illuminating power, purity, and pressure of the gas supplied by the said Company at any testing place belonging to the said Company, be represented by some officer, and the said Company shall state at what times it is proposed to make such testings on any particular day upon receiving a request in writing from the said Corporation in the forenoon of the previous day.

11. A representative of the said Corporation shall from time to time, after giving notice to the said Company, visit the testing places of the said Company, for the purpose of ascertaining that all instruments are kept in good and proper repair and working order.

12. The said Company shall on each day make and deliver to the said Corporation a report of the result of the testings of the gas supplied by the said Company for illuminating power, purity, and pressure conducted by the Gas Examiner to the said Company, on the immediately preceding day, and the books kept by the Gas Examiner to the said Company for recording the results of the testing of such gas by him shall be open at all reasonable times to the inspection of the said Corporation.

Note.—Here follow similar clauses *re* Corporation testing places.

17. The general procedure in conducting tests for illuminating power, purity, and pressure of the gas to be supplied under this agreement at the various testing stations shall be as described in the various clauses and appendices of this agreement.

18. The said Company may at their own expense cause to be affixed to each public lamp the instrument known as a street-lamp governor, of a pattern to be approved by the said Corporation, and the said Corporation shall be entitled at all times to have access thereto for the purpose of examining the same.

23. The said Corporation may at any time during the period of this agreement alter the position, or increase or reduce the candle power, of any public light or lights. But the said Corporation shall pay to the said Company, at a rate to be mutually agreed, the cost of taking up and relaying any pipes which may be necessary to reach the altered position of such public light.

24. The said Corporation undertake that an irreducible minimum of 9000 public lights, irrespective of position, candle power, or consumption of gas, shall be kept burning for an average of ten hours each night, or an annual average of 3650 burning hours per annum. Should the said Corporation for any reason desire to reduce the number of public lights below the said 9000 they may do so, but they shall be bound to pay to the said Company the same amount for gas as if the said 9000 lights were burning for the minimum of 3650 burning hours per annum.

28. The words "minimum pressure" used in the various clauses of this agreement shall mean the lowest pressure at which gas is supplied to any public light in any part of Calcutta when all the lights are burning, measured at a point between any governor, or regulating device or cock, and the burner when the burner is lighted.

29. The pressure at which gas is supplied in accordance with this agreement is expressed in terms of the number of inches or 10ths of an inch in height of a column of water which such pressure will counter-balance.

30. The minimum pressure at which gas shall be supplied by the said Company during the hours of public lighting to each and every public light in Calcutta shall be as follows:—

(*a*) For the first five years of this agreement from the 1st day of May, 1911, to the 1st day of May, 1916, not less than two inches.

(*b*) After the 1st day of May, 1916, not less than two and five-tenths inches.

(*c*) Should the said Corporation after the 1st day of May, 1916, desire to increase the minimum pressure over and above two and five-tenths inches, the said Corporation may do so by giving to the said Company notice in writing, when the said Company shall be bound to increase the minimum pressure to an extent not exceeding a total minimum pressure of four inches on payment of the increased price arranged in clause 39 of this agreement. Any increase of pressure shall not be less than $\frac{5}{10}$ths of an inch, and shall be in multiples of $\frac{5}{10}$ths of an inch.

Note.—Here follow clauses as to penalties for defects in illuminating power or purity of the gas.

37. The measurement of the quantity of gas consumed by the public lights shall be estimated from the average consumption of gas by at least 30 of each size of gas-nipple to be used by the said Corporation, when tested in the following manner. A test gas-meter, such as is used for photometric measurements, shall be used having a capacity of $\frac{1}{10}$th of a cubic foot for each revolution. The water-line of this meter shall be adjusted by means of a Gas Referees $\frac{1}{10}$th of a cubic foot measure. A suitable fitting shall be attached to the outlet of the meter in such a manner that the nipple to be tested can be readily attached. A King's pressure-gauge which has been carefully verified with a column of water shall be attached to the above fitting at a point close to the nipple to be tested. The pressure will then be carefully adjusted to the pressure at which it is desired to know the consumption of gas by the nipple. A test will be made of each nipple for ten consecutive minutes, and the quantity of gas passed through this meter during these ten minutes as recorded on the dial shall be multiplied by six to make sixty minutes, and the gas thus calculated to be consumed in sixty minutes shall be accepted as the hourly consumption of the nipple which has been tested. The average hourly consumption of gas by 30 of one size of nipple, selected at random, at any one pressure tested in this manner shall be accepted by the said Company and the said Corporation as the hourly consumption of gas by this size of nipple when used in a public lamp at the pressure at which it was tested. Should it be found that the pressure of gas is not evenly distributed in all parts of Calcutta, and the said Corporation is satisfied that such unevenness is unavoidable, and likely to be permanent, the said Corporation shall agree to nipples being tested of a size which will be suitable for pressures higher than the minimum pressure prescribed in this agreement. The consumption of gas in cubic feet per hour of each burner estimated by a test of the gas-nipple in the manner aforesaid multiplied by the estimated number of hours each burner is lighted, shall represent the quantity of gas supplied by the said Company and to be paid for by the said Corporation.

40. The said Corporation and the said Company may cause to be erected, at suitable sites in various districts of Calcutta, recording gas-pressure gauges, which shall correctly and continuously record on paper the exact pressure at which gas has been supplied during the 24 hours of day and night. Each of these recording pressure gauges will be placed in such a position as to record the pressure at which gas has been supplied to not more than 2000 public lights. The pressure recorded by these recording pressure gauges may be deemed to represent the pressure at which gas has been supplied to the number of public lights which each pressure gauge controls. The said Corporation may test the pressure at any individual public light, or any portion of any such district, if they have reason to believe the pressure to be lower than that recorded on the district pressure recorders.

Note.—Here follow clauses as to penalties in case of defects in pressure. An appendix giving full details as to apparatus and method of testing is attached to the agreement.

APPENDIX II.

Extract from the Westminster City Street Lighting Contract.

SPECIFICATION OF LIGHTING.

See General Conditions of Contract.

1. The subject matter of the contract is the lighting of all or any of the districts in the City of Westminster.

The contract so far as it relates to "Installation" includes the provision of any necessary mains, wires, shades, apparatus, lamps, burners, governors, cut-outs, switches, resistances, reflectors, and other fittings necessary for the satisfactory installation of a satisfactory system of lighting of the type quoted for and the execution of all incidental works of every kind, including the cost of the making good of any pavement disturbed, which last mentioned work will be carried out at cost price by the Council at the cost of the Contractor.

The contract so far as it relates to "Maintenance" includes the provision of the illuminant, and the cleansing, lighting, and extinguishing of the lamps, the provision of any carbons, mantles, or any other fittings of any kind to ensure the same burning efficiently, and all repairs necessary to the things provided for in the "Installation" contract from whatever cause arising.

The illuminant shall be of the minimum specified candle power.

The period of the commencement of the contract so far as it relates to maintenance is the day following the expiration of the existing contract relating to the district in question. Particulars of the dates of expiration of the existing contracts are given in the "schedule of lights as at present existing in the four districts." The Installation works must previously be completed in accordance with the "Conditions of Contract."

2. The contractor shall provide all materials, labour, tools, tackle, implements, plant, water, and other necessary things for the proper execution of the works. All the materials used shall be the best of their respective kinds, and applied in the most workmanlike and substantial manner possible, and the work shall be executed to the entire satisfaction of the City Engineer, who shall have full power to reject any materials which he may consider unfit to be used in the work.

3. In the case of "large units" the lamps are to be erected on suitable and approved columns of such a height that the centre of light shall not be less than 20 feet above the adjacent surface of the ground. In the case of "small units," the centre of light shall be not less than 12 feet from the adjacent ground surface.

4. The design of electric lamp pillars is subject to the approval of the Council, and such pillars must be of cast iron or cast iron and steel tube construction. The approved type of gas-lamp columns is that recently erected in Whitehall and Parliament Street. In the case of electric lamps, provision must be made for the winding gear to the footway columns. Arc lamps shall be fitted with automatic substitutional resistances, so that the failure of one lamp will not interfere with others in the same group.

5. Each lamp is to be fitted with burners, mantles, globes, and fittings, as the case may be, giving a minimum of 90, 180, 1800, or 3000 standard candle power, respectively, as directly measured by the Council's portable photometric apparatus placed at ground level, and is to burn 3940 hours per annum in accordance with a daily schedule to be hereafter supplied by the Council. The fittings and lamp must be in every respect to the satisfaction of the City Engineer, and in particular the reflectors above the light are not to be concave to the light so as to concentrate the illumination at the foot of the lamps, but horizontally, flat, or slightly convex as approved by the City Engineer so as to disperse the rays. The tests will be taken in such a manner as to ensure that glazing bars shall not interfere with the results obtained. The candle power shall be arrived at by taking the average of two readings in any position with regard to the light under test, one reading at an angle of 20 degrees and a second reading at an angle of 50 degrees to the horizontal. A test standard unit of 1-foot candle or of any size in excess of this up to 10-foot candles may be used according to the character of the photometer with which the tests are made and the class of lamp being tested, all as the City Engineer shall direct. The photometer shall be of the Simmance-Abady Flicker type, or of any type approved by the City Engineer. The intention of this contract is that the Contractor shall assure himself by continued test and inspection that the lamps he provides are during lighting hours fulfilling in all respects the requirements of this contract, and he shall not claim relief from the conditions of this contract on the grounds of non-notification on the part of the Council of any failure to comply with the terms of this specification. The light given shall be of a steady, invariable character, of a white or yellowish-white colour.

6. The whole of the metal work of the lamps shall be cleaned down and painted once in every two years with two coats of oil paint, the last coat being mixed with hard-drying outside varnish, of the special shades of colour generally used by the Council for lamps and as required by the City Engineer, after thoroughly scraping and cleaning. All old paint shall be completely burnt off once in every four years, when three coats of paint, as before mentioned, shall be applied instead of two coats. The painting shall be done at such time of the year as shall be approved by the Council. The glass shall at all times be kept thoroughly clean.

7. The whole of the installation is to be complete and in thorough working order by the time specified.

8. Such of the existing pillars and lamps as are now the

property of the Council may be used in present positions, free of cost, subject to adaptation as particularized in Tender Form, if they can be adapted in such a manner as to have the approval of the Council. In case any new lamps or parts thereof are required under any scheme submitted by any tenderer, the existing lamps shall be carefully taken down, and, if the property of the Council, shall become the property of the Contractor, who should make allowance for the value of the same in his tender. The existing mains, surface boxes, &c., are *not* the property of the Council. Possession of the existing lamps, columns, &c., will be given at various dates prior to the end of the year 1910.

Discussion.

The PRESIDENT said they were all much obliged to Mr. Abady for an extremely useful and most interesting paper, which those who had not already done so ought to carefully study, for they would find in it a great deal of what would be useful to them in connection with the lighting of the towns they represented.

Mr. C. E. BOTLEY (Hastings) said he had listened with great attention to the remarks made by Mr. Abady; but he had not had an opportunity of reading the paper, and therefore he might perhaps make some mistake in the observations he was about to offer. There could be no doubt that the principles the author had enunciated as desirable in providing public illumination were those with which they could all agree, whether they were engaged with gas companies or municipal authorities. All that was desired was that there should be fair competition with regard to public lighting, and that things should be treated on their own merits, without side-issues being interposed. The paper was headed "Public Lighting from a Municipal Point of View;" but this was open to two interpretations. He knew the interpretation put upon it by the author; but there was another put upon it by municipal authorities. In many instances, it was not a question of electric lighting or of electricity value, but of a municipal electricity undertaking which was competing against a private gas company; and in such a case as that, the principles set forth in the paper would be of no consideration whatever. It was not a question about getting the best light in the interests of the ratepayers, but of the employment of their electrical undertaking, perhaps, to give an inferior light at an increased cost. And so they sometimes said: "We don't care a hang what light the ratepayers get; we have a municipal undertaking, and we are going to use it for lighting the streets." If this point was dealt with in the paper, he must apologize for mentioning it. They would all agree that this was most unfair. He quite admitted that if a municipal undertaking could provide a better light at a lower rate than it could be supplied for by a gas company who were large ratepayers, they were justified in doing it, but not otherwise. Generally speaking, an electricity undertaking did not pay. It contributed very little towards the rates; and therefore the ratepayers were paying an increased price for the lighting, and getting no benefit either in the rates or in the amount of light. The question of the distribution of light was most important. The arguments put forward, that so many thousand candle power was offered by electricity in excess of what was offered by gas, were absurd when put into practice; but he was afraid that, with so large a number of electricity undertakings in the country as were now carried on by corporations in competition with gas companies, the question of securing the best light at the lowest cost had no consideration whatever.

Mr. F. W. GOODENOUGH (London) said he had not much to say on the paper, except to congratulate the author upon it, and the Institution on getting so admirable a communication on its records. He was quite sure, when the members came to study the tables it contained, they would find them of the greatest value and assistance. The author spoke of what "everybody knew." But common knowledge was something like common sense—a thing that was rarely found at the moment one wanted it. The tables in the paper would form a basis on which to decide what was the proper arrangement of lamps in a street; and they were just the tables which he had been intending to produce for the last seven years. He was much obliged to Mr. Abady for having done what he (the speaker) had not found time to do. He had frequently had to work out a street-lighting problem by itself, simply because he had not the tables which were now before them, and which would form an admirable basis for any lighting scheme. He could quite sympathize with Mr. Botley in his strong feelings about municipal trading. They had had something to do with it in regard to lighting in bygone years; and he knew of one borough which was spending about £6000 a year more on its street lighting than adequate gas lighting would cost. They had already taken from the ratepayers about £37,000, in direct contributions from the rates, to make up their deficit. So that in about eight years the scheme in question had cost the ratepayers something like £80,000 in excess of the cost of street lighting and in contributions to make up the deficit. But if they were to take Mr. Abady's principles to them, and asked them to scrap their arc lamps because the nominal candle power was not of practical value, they would say, as Mr. Botley had remarked, that they had their own baby to feed and were going to feed it. One could only wish that all municipalities had on their committees men with the same expert knowledge of street lighting as Mr. Abady. The difficulty was frequently to get a municipal committee to thoroughly understand lighting problems. His figures erred, if anything, in favour of the high-power light, because he was comparing the value of the light on the ground level. For instance, he was taking a lamp-column 11 feet high and dividing the light by the square of 11, and then a lamp-column 20 feet high and dividing by the square of 20 or by an angle line; whereas the actual practical level at which the light was required was at an average of somewhere about 3 to 4 feet from the ground. This was about the height at which one looked at a watch; and if they took from the ground level to about 8 feet above the ground, this was about the area for which the light was actually used. If they took the mean of this, and measured from there to the height of the column, they would get a still stronger argument in favour of small units and low posts. Still, if 3-candle power on a 20-feet post was required, they were quite prepared to deal with it. Such a light would be found in Aldwych; and if anyone was interested to see the latest thing in high-pressure inverted gas lighting, he should go and see it. It was not an economical light; but it was a very good advertising light. He joined issue with Mr. Abady on the question of upright as against inverted burners for street lighting, because he quite believed that the inverted burner was the burner of the future for this purpose. Its efficiency was very high, and with a proper reflector its distribution was very good. He did not quite follow the author's point as to the authority making a contract to secure for the ratepayers the advantage of progress in efficiency during the period of the contract, because if the municipality entered into a contract with a company for a 100-candle power light for five years, and if during this time the gas company could give this candle power with half the gas it started with, those who benefited were the company, not the municipality. It seemed to him that the gas supplier or the electricity supplier had all the advantage from increased efficiency obtained during the period of the contract. In conclusion, he again recommended the members to study the paper very carefully, and to keep it at hand for reference.

Mr. GEORGE HELPS (Nuneaton) said he should like to join his thanks to Mr. Abady for his admirable paper; for he had dealt with the matter in the very thorough way they all expected from him. To attempt to discuss all the points raised would be impossible; and, as there was a good deal in which he was absolutely in accord with the author, he need not go into that. But on two or three points on which he was not in agreement, he would make some few remarks. Mr. Abady said he did not think the gas sold by nipple consumption was so good as something else; but what that "something else" was, he (Mr. Helps) did not quite understand. They all knew the importance of pressure; and he had sometimes thought money would be well spent if the Research Committee of the Institution used some of their energies in the direction of trying to discover, while some of them were alive, how to send out 18-candle gas at 10-10ths or 15-10ths pressure. They also knew that low-grade gas was far more useful to their customers than high-grade gas; but he did not know whether they thoroughly assimilated this knowledge. When they did, it would be far better for the consumer. They could all understand the importance of the height of the light from the ground; but there, again, perhaps they did not appreciate it, because, if they looked round, they saw many lights which were not of the height they should be. He was more at variance with Mr. Abady when he said he believed the vertical mantle was better than the inverted one, than in any other remark he made,

because he thought he was absolutely wrong. He should like to show him some lighting with which he had had something to do at a large railway station where they had vertical burners, and were replacing them by inverted ones. There the consumption had been reduced 25 per cent., and the light had been considerably increased. He should be much indebted to anyone who could show that these were not the facts. There was one matter which he thought had been omitted, and it was of huge importance in a scheme of gas lighting—viz., maintenance. The maintenance of an inverted burner against a vertical burner was a very big feature indeed. He had some figures with him showing, over eighteen months, the number of mantles actually used in inverted and vertical lamps. The number of lamps was 400, and the vertical mantles were in ordinary square lanterns which were not originally made for incandescent lights, and consequently were not the best fitted for the purpose. But the actual mantle consumption over several years worked out at 24 mantles per lamp a year. The cost of the mantles was, of course, not the only consideration, because the labour in dealing with them was also an important matter. A good many people imagined that they only used three or four mantles in a lamp per annum; and they might go on imagining it. But if they kept a true record, they would find the number would approach much nearer to the figure he had given than they would at the moment credit. In the case of inverted burners, the number of mantles used had come down to less than six.

Mr. C. E. Jones (London) said, if his memory did not deceive him, it was 35 years since he read his first paper on street lighting; and at that time very little attention was paid to such a subject. It was thought to be the correct thing to sell as much gas as one could, irrespective of the illumination got out of it. He remembered a director of a company with which he was then associated who objected to improvements in burners, and wanted the old iron burner all along; his reason being that it consumed more gas than the new-fangled burner then being put on the market. This was a fair type of a large number of administrators of gas companies 35 years ago. But they saw a great difference now. There was a wonderful change in the street lighting of all towns. As a fellow-citizen of Westminster with Mr. Abady, he could not allow the opportunity to pass without expressing his congratulations to him for elevating this subject of street lighting from the pavement to a higher level; and he not only congratulated him, but also the Institution on possessing a paper which would adorn its "Transactions." The value of lighting, not the value of the gas, was what they were now taught to consider. It was too late to say that a lamp was taking so much current, or that they were supplying so many cubic feet of gas per hour to the lamps. What they wanted to see was what they were getting out of it. The proper basis of a contract was an intelligent idea of illumination—what was the illuminating effect of the gas or the electricity. Then came the great point to a commercial people—the question of cost. He might tell the members that Mr. Abady had a very uphill fight in Westminster over this matter; but they had stuck to their guns. In his municipal capacity, he had been a stalwart; and he (Mr. Jones) was pleased to say he had voted for him. Everyone interested in gas ought to feel indebted to Mr. Abady; and, if his idea were adopted and carried into full effect, he (the speaker) had not the slightest doubt that the City of Westminster would be the best-lighted city in the United Kingdom, and he hoped in the world—bearing in mind always, the security that it gave for the protection of life and property. He had always contended that one gas-lamp was equal to three policemen; but this was in the old times, when they did not get much illuminating power out of gas. Now, with a decent burner, they could obtain 100 candles easily out of 30 to 40 cubic feet of gas, which was an unknown quantity in his young days. According to the calculations of the electricians, it was possible to get thousands of candle power out of one light. They multiplied by 32 all the points of the compass, so as to get the volume of their light by the square of the distance, and all that sort of thing. In Mr. Abady's system, they had an elevation of the subject. It was reduced to mathematical accuracy; and the author deserved their thanks for bringing it before them in so clear a manner. He desired to endorse particularly what Mr. Abady said about high-pressure gas. Assuming the distributing apparatus and the fittings were correct, there was no reason why gas should not be distributed now at much higher pressure than it had hitherto been; and the time was coming when it would be. He had advocated it in the Institution; and he had told the members, if they could not make tight mains, to send for water engineers, who managed to lay down mains for carrying pressures which gas men knew nothing whatever about. Having got their mains and apparatus completely gas-tight, there was no reason why gas should not be supplied at much higher pressure than it was now. In his domestic economy he had only one fire—a gas-fire. All his food had been cooked by it for the last fifty years, and he did not think he looked any the worse for it. But they must have higher pressure gas for cooking purposes. In his judgment, the paper was a most valuable contribution. It marked a new departure, and inaugurated a better feeling between municipalities and the purveyors of artificial light. He was glad to think that the City of Westminster had taken the lead in this matter of street lighting.

Mr. R. G. Shadbolt (Grantham) said he should like to add a few words from the point of view of a Company's Gas Engineer who had to meet the requirements of a municipality. In his own case, he had laid down similar lines to those advocated by Mr. Abady; and he might remark on the very masterly style in which that gentleman had placed all the members under deep obligation to him by preparing the tables in connection with his paper; and by the lucid manner in which he had presented the subject, so that any ordinary director or member of a committee could follow the lines of his argument and the basis on which he had worked out his tables. Having had the opportunity of reading the paper, he must confess that not only in the main but practically throughout he found himself compelled to agree with the author in what he said with regard to the vertical burner, as to the distribution of light, as against the inverted one. His observations on the placing of the lights, on the reflector, the height of the light, and the decrease in the unit of light, were most valuable features of the paper. Having had occasion, some few years ago, to enter into competition with an electricity undertaking (fortunately a company) over a long-standing contract where they supplied everything, even the lighting, cleaning, and all the rest of it, on the old basis of so many cubic feet an hour to a certain number of lamps, and so many cubic feet to another set, and having turned-over from this to practically an electricity specification, the members could appreciate—after an experience of two terms of three years in which he beat his electricity competitor out of the field, and having entered on a further term of five years for which they had secured the contract for the entire lighting—his desire to speak. He quite agreed that the entire system of lighting—providing, maintaining, extinguishing, and so forth—was to-day much more satisfactory, from the point of view of the supplier, than it was; but possibly not in Mr. Jones's time, because they would find that, where the gas company maintained the lamps as well as supplied the gas, more particularly if this was done under penalty clauses and tests, the lights were, generally speaking, in far better condition than those which were left to the local authority to maintain—the gas company being simply responsible for the gas. Again, there was the great advantage of the advertising value; and he thought even Mr. Abady would be very much at sea if he attempted to estimate it. One could not by testing estimate the value of retaining the entire street lighting of even a small country town. On the other hand, like all other things, it was quite possible to go to an extreme. He had in his mind a neighbouring town where the electricity people were ousted from the public street lighting quite recently by the local gas company; and the chairman of that electricity company made a remarkable statement at the general meeting. He said he was sorry to say that the sale of current had considerably diminished owing to the loss of the public lighting; but, on the other hand, he was glad to be able to report that they could pay a little better dividend than before, because they had been relieved of an "advertising incubus." It was quite possible to quote a figure in order to get a contract, if one had to tax unduly the ordinary consumers. This might apply more to electricity as a competitor than to themselves. He thought that in most gas-lighting contracts there was not the slightest difficulty in putting them on a fair basis. In a general specification, they were still able to take the lighting at a lower price than their competitors, and to do it remuneratively. With regard to the Calcutta clauses, and their bearing on the point of view of gas companies' engineers supplying according to Mr. Abady's requirements, he

did not know what his intention was; but it seemed to him (Mr. Shadbolt) that this was a specification which ought, by all possible means, to be avoided, for the simple reason of the undue interference it contained with various applications of gas, by limiting the illuminating power, specifying the pressure, and putting on all kinds of restrictions, simply to ensure that the corporation or the municipality might receive a given quantity of gas. The spirit of these powers, from beginning to end, seemed to him to leave the supplier to furnish a specified quantity of light distributed in a certain manner, but not to give him a free hand to use various improvements as they came along. Although the supplier might benefit with regard to one term, it was the municipality who benefited when the next term came round, because the gas supplier would be able to quote a lower figure owing to the experience he had gained and the various improvements he had been able to introduce.

Mr. H. W. Copp (West Bromwich) said towards the end of the paper the author made a statement to the effect that at present the most efficient means of street illumination was that of a particular electric lamp, which he believed was No. 15. He took it that Mr. Abady meant that this lamp possessed greater efficiency owing to the arrangement of its components, not necessarily that it was the best agent for illuminating streets. The paper was a complete guide, so far as public street lighting went, with regard to the arrangements which ought to be made between a company and the public authority. But he could assure the author that the same difficulties very often existed with the municipal supply as well, though with this difference—that with regard to a company supplying light they generally had a free hand, and their success depended more or less on their own merits, whereas in a municipal concern the whole thing was frequently biassed. One reason for this—especially in remote Provincial towns more than in those near London—was that there was a great prejudice in favour of electricity, solely due to a popular idea that it was more up-to-date than gas lighting. This was one point requiring to be strongly combated. With reference to the question of efficiency—supplying so much light for a certain amount of money—the tests specified by Mr. Abady were very complete; but he thought that tests should not altogether be relied upon, and that common sense was an important factor. His experience was that it was not always the quantity of light that mattered. In some places, the public preferred glare to illumination. The feature was one which the people responsible for public lighting should also bear it in mind. Two or three years ago, when he had the honour of reading a paper on street lighting before the Institution, he had occasion to study this subject rather thoroughly; and he came to the conclusion, after trying a number of experiments with large units of different types, and also with single burner inverted lamps, that the ideal in street lighting was small units at a fair height, close together. He proved this to his own satisfaction; and he thought, by reference to the paper, it would be seen that the point was fairly clearly shown. Another thing he should like to refer to was the subject of reflectors. As he said in the paper, the point seemed to him to turn mainly on the efficiency of the reflectors, especially in the case of inverted burners; and his own opinion was that the ideal public lighting would be eventually found to be the inverted burner with suitable reflectors for diverting the light in the direction of the roadway. He was not himself prepared to submit a design for a reflector which would effectively do this; but he was convinced it was possible, and that in the future someone would discover the right form of reflector to attain this end. With regard to the first appendix to the paper, in which Mr. Abady set forth the lighting conditions at Calcutta, he (Mr. Copp) did not think they were altogether to be congratulated on confining themselves, as they did, to low-pressure gas for the next twenty years, because his opinion was that, for practical purposes for the public lighting of large towns, low-pressure gas would soon become almost obsolete.

Mr. T. Canning (Newport) said he should not like the paper to pass without some notice from himself, as he had had considerable experience of what a municipality was attempting to do in the way of public lighting. But before saying anything on the matter, he should like to refer to one reason why he so highly appreciated the paper. It was because it was scientific, and because the author had attempted to make a contract upon what he might call a scientific basis. He believed the Westminster contract to be founded on a scientific and proper basis; and he commended this portion of the paper more especially to the attention of the members of the Institution. He had made some experiments with public lighting, both with gas and electric lamps; and he generally found, taking various zones at certain well-apportioned distances from the base of the column in either case, that the principles laid down by Mr. Abady were the general scientific principles governing the intensity of light compared with the distance applied to gas-lamps. But he had not found them apply to electricity lamps; there was some other quality which interfered—the quality of non-diffusiveness. At a certain distance from the zone, the light given by a gas-lamp was greater than that given in the same zone by an electric lamp, although, if tested photometrically, they would both be shown to be of the same intensity at the source. He should like, therefore, some further explanation on this point. It was a matter he had observed; and he could only say that it was not an explanation that the light coming from the electric arc or from the incandescent filament might be very intense at the source, but did not seem to be diffusible. It was something like what he saw some years ago in South Wales. A very able man, before the days of patent fuel, brought out a method of compressing coal dust. It was his own; and it had not been repeated. Its calorific power was stated to be tremendous; and so it was. But when it was used under boilers, its intensity was so enormous, and its want of diffusion so remarkable, that it performed scarcely any work whatever in the boiler, although under the boiler it did a great deal of disastrous work. So much with regard to the scientific side of the paper. He welcomed it because it was an attempt to work out a very difficult problem, and to give them a chance of making a proper and fair scientific comparison between gas lighting and other methods of lighting competing with it. With respect to the question touched upon by Mr. Botley—viz., the manner in which municipalities dealt with gas companies when they happened to have an electrical establishment of their own—he must remark that in a particular case of which he knew, there could not be said to be any competition whatever. The electric light installation went up as soon as the municipality in question became the proprietors of the electric power works: and the gas company had to offer, but were not asked, to tender. He was not sure whether this was in accordance with the Act of Parliament which had been passed regulating the action of municipalities; but he distinctly thought it was illegal. He had said so elsewhere, and he thought he should not be going too far in repeating it. At any rate, the gas company in the particular case referred to had had to offer their tenders voluntarily, with the certainty that they would be rejected, and with the equal certainty that no knowlege of their existence would be given to the public—that, in point of fact, they would be suppressed. Again, certain tests had been asked to be made between the electric light and gas light; and they had been scornfully refused, because the statement of the corporation, through the electricity department, was that they made a commodity of their own which the ratepayers owned too. Certainly, it ought to be their own, as they paid two or three times over for it. But they said this commodity was theirs; and because it was theirs they would use it for their own purposes. He wished to point out, in a plain, common-sense way, how they might have evil consequences. Some years ago, he knew of a firm who were about to establish themselves on some good marsh land where there was excellent clay for brick-making. He advised the firm to have nothing to do with brick-making. But they said they would; they had the clay, and the bricks would be their own commodity. And so they were. They tried to put the bricks into the building; but it came down because the bricks were no good. They were the firm's own commodity, but were the worst commodity they could touch; for after they had made the bricks they had not the heart to condemn them. So, in like manner, they never got the electricity department of a corporation to condemn its commodity, no matter how bad it really was. Once they got it there, they would continue to use it. All this sort of thing going on had, no doubt, a very evil effect, so far as gas companies were concerned. The public thought it was through some fault of their own—through some want of power in the light, or some disadvantage on their side—that they were unable to do what was required with respect to the public lighting of the principal portion of a town, but were relegated to the side streets, where it was too expensive to take the electric cables. The gas company were ratepayers—often very

heavy ones—and had to pay a portion of the cost of public lighting; and when the electric lighting concern went on from year to year losing money, and falling back on the rates to the extent of some thousands of pounds, he thought that when a public Government inquiry was held, the gas company ought to come forward and state the whole facts of the case. He did not say they ought to show any spirit of animus or unreasonable opposition, but simply and solely to state the facts of the case. The community had a right to have its own electric lighting and to supply it, and also to have loans from time to time authorized by the Local Government Board for carrying on the work. To this they had no objection; but it was to the system, which was so unfair, by which they were relieved entirely from competition, and by which they only retained their standing by selling current frequently below cost price.

Alderman GRIFFITHS (Southport) said, as representative of a municipality, he was much interested in the paper, which appeared to be a valuable one for gas undertakings. But he was not interested in the discussion upon it, as it seemed to him to savour too much of private companies *versus* municipalities. He thought the question for an Institution of the character of that of which those present were members, ought to be the gas industry, the whole gas industry, and nothing but the gas industry. It so happened that his municipality owned both the gas and electricity undertakings, and they lighted the streets by gas. He thought it was wise—and this was why he rose to speak—to look at both sides of all questions. It was very foolish for an institution devoted to electricity to say too much about gas; and equally inept for a gas institution to say too much about electricity. Each would be wiser to attend to its own business. As his municipality had both undertakings, he was in a somewhat impartial position; but he was Chairman of the Gas Committee. He found, whether the Institution did or did not realize it—but they would have to do so—that the public required electricity both for house and for street lighting. He found in his own town that every house of more than £20 value was being wired for electricity, and not being piped for gas. So that the Institution would have to take full account of what their customers were very largely demanding—a supply of electricity. He hoped that the President's advice would be taken into serious consideration at an early date, and that there would be absolute cohesion between the companies and municipalities who supplied gas; for he thought this was the only way in which the gas industry could properly maintain its present important and useful position.

Mr. ABADY, in reply, said the lines the discussion had taken showed the great advantage of the form that he had adopted for presenting his paper, because practically every point which had been mentioned was contained in it, and therefore the discussion only showed those points which were foremost in men's minds. There were two subjects which seemed to run through the remarks of most of the speakers; and therefore he would deal with them without reference to anyone in particular. One was the question of the woeful position of a gas company owing to an electric corporation undertaking; and the other was the question of the Calcutta contract, which he had dealt with at length. With respect to the municipal question, he had touched upon it in the paper; and he thought if anybody read it he would see this was so. But he felt that a general discussion as to how to combat the Collectivist tendency of the present age was somewhat outside the scope of the subject he had in hand; and this was the only reason why he left it alone. As a politician, he had his own views on the question, and he should like to have the opportunity of occupying the rostrum for an hour or two upon it. But it really had nothing to do with lighting. What he did suggest was that they wanted, in the matter of lighting, a thorough understanding of the real meaning of what the competitor's offer was, as this would enable them better to combat municipal competition. That was the point. With respect to the Calcutta contract, he did not think those gentlemen who had mentioned it could have read the text of his remarks carefully, or the clauses of the agreement he had quoted. The contract was one which replaced an existing contract that was for the supply of so much light; and, under the circumstances, in a city like Calcutta, where the principal use of gas was for public lighting, and where there was native labour as well as all sorts of difficult conditions to cope with, a contract for a long period was necessitated. This, he learnt from the source from which he obtained the information, which was authentic, had been found unsatisfactory, and it had become necessary to make the agreement for a nipple test. He put the agreement in because he thought it was so admirably complete. It was suitable for Calcutta; and, for its circumstances, it was admirable. But he ventured to think it was not in a general way, where ordinary and normal conditions prevailed, an advantageous form of contract in the same sense as was one for the supply of light. One or two statements had been made about it which were not correct. It did not tie them down to low pressure. There were very elaborate precautions by which an increased pressure could be taken advantage of when this became, so to speak, the fashion. He did not think the Calcutta Corporation looked upon the matter from the point of view of shackling the Gas Company. All they wanted to have was power to buy the gas, and then to look after the lighting themselves. This was the position they took. Under the circumstances, remembering what they knew of the matter, this was inevitable. But he did not think the general observations which had been made would have been offered if the facts had been clearly understood. Mr. Botley had dealt with the municipal question, and was good enough to preface his remarks by saying that he had not read the paper. If he had done so, he would probably not have made them, as they simply confirmed what he (Mr. Abady) had said. Mr. Goodenough asked how the photometric tests enabled a municipality to take advantage of any improvement. It seemed to him that this would be to the advantage of the gas company, if not to the municipality. In reply to this, he might simply refer to one passage in his paper: "Does this contract facilitate or encourage the adoption by either party of improved methods? It seems to me that it does, because if the contractor finds he can produce the same light at a cheaper cost, or a better light for the same cost, he would surely approach the corporation and offer to share the benefit of such improvements." He did not suggest that the Directors of the Oriental Gas Company or the Engineer was an angel without wings; but he was reasonably certain that improvements in lighting would come through the adoption of a burner which enabled gas at an increased pressure and of a lower quality to be utilized. Therefore the mere change in conditions would probably necessitate the provision of a new burner or apparatus of some kind; and no gas company could afford, in the middle of a contract period, to voluntarily go to the expense of a new burner for the saving it would effect in the gas. But the Gas Company would go to the Corporation and point out that there was efficiency to be obtained, and a saving to be effected, by capital expenditure on a new burner, and offer to share the benefit and saving with them. In this respect the Corporation were quite safeguarded. With regard to the question of whether or not the light on the ground was the light that was wanted, he had really not taken the actual light on the ground. He had taken the light at the source, and divided it by the square of the distance from the source to the ground, so as to be comparable all through; and this was something definite. One man might want to read his watch at the height of 4 feet, and another at 4 ft. 6 in. But if he dropped a threepenny bit or a half sovereign, he would want the ground level. Mr. George Helps said he did not understand what he (Mr. Abady) was trying to get at in comparing the nipple with "something else." But when Mr. Helps had read about the "something else," and had arrived at a definite conclusion as to what it meant, he (Mr. Abady) would be willing to discuss it with him. With regard to the vertical burner, Mr. Helps and a subsequent speaker quite misrepresented him. He did not say that the vertical burner was the most suitable for street lighting. He said that the natural distribution curve of the vertical burner was more suitable for street lighting than that of the inverted burner, but that the inverted mantle saved in maintenance. The mantles would give a better light with less gas; and therefore, if they were to be used efficiently, the unnatural distribution of the light must be provided for by the position in which they were placed in the lanterns and by the use of proper reflectors. He agreed with what had been said by Mr. Shadbolt, who had had experience of a contract for the supply of light; and he also agreed with the inadvisability of maintenance by the local authority, subject to special circumstances, such as those at Calcutta. Mr. Copp was in error about the most efficient lamp. What he (Mr. Abady) said was that, in settling the question of the distribution curve, the best example was the flame arc lamp; and they got the distribution by using dioptric reflectors—a type

advocated by Mr. Trotter many years ago, which might be investigated further by those who were responsible for the design of gas-lamps. Efficiency could not be diverted from price; and that the flame arc lamp was not the most efficient in all circumstances was shown by the fact that 3000-candle arcs were coming out in Regent Street and Piccadilly, and were being replaced by high-pressure gaslight, because this was more efficient at the price. He could not agree with Mr. Copp that one ought to give way to the popular outcry for glare, as compared with the proper distribution of illumination. He did not believe in glare. It might be necessary, in the interests of advertisement or a lack of common sense in the public, to give them big units which would dazzle their eyes. He was glad to find himself in agreement with Mr. Copp in his advocacy of small units on columns of fair height placed close together. He should like to take the opportunity of acknowledging the excellence of the contribution which Mr. Copp had made, and the service it had since been in the design of burners. With regard to Mr. Canning's remarks, he could not discuss the question of brickfields or municipal trading, because it was somewhat out of the scope of the paper. As to the question about the difference between the effect of an electric and a gas lamp, if there was any explanation of the phenomenon he considered it probable that to a certain extent gas would give better penetration on a foggy or misty day than an electric lamp; and he thought this was due to the fact that, as a rule, when persons talked about an electric lamp they meant an arc lamp. The source of illumination in an arc lamp was very small—just the arc itself at a very high intensity; whereas the source of illumination in an incandescent mantle was much larger, but the area of the illumination was not of anything like such intrinsic intensity. Consequently, one got a light that was better diffused. This would apply to a filament lamp as well. No doubt it was true that one could only measure photometrically the light at different angles, adopting the square of the distance. He entirely agreed with Alderman Griffiths that a spirit of impartiality should pervade their discussions. It was much better to make one's own house efficient than to grumble because somebody else's was better. He had tried to maintain this spirit in the paper; and he could assure him that the same spirit pervaded the municipal work of London with which he was connected or acquainted. Of course, the question of municipal trading was a very difficult one, and it might form a suitable subject for discussion; but not on such an occasion as the present.

GAS HEATING RESEARCH.

SECOND REPORT OF THE "GAS HEATING RESEARCH COMMITTEE" Appointed by the Institution in Conjunction with the University of Leeds.

Prefatory Note.

In their report of last year, the Committee recorded a series of experiments on open gas-fires, carried out by Mr. E. W. Smith, with the object of obtaining a heat-balance with as much accuracy as possible, and especially with the object of determining the output of radiant heat.

On resuming the experimental work, Mr. Smith first addressed himself to improving the apparatus used for measuring radiation, and then proceeded to study a considerable variety of stoves supplied by different makers.

Experiments were made upon the relation of gas consumption to radiation efficiency. Another series of experiments was made on the relation of composition of "fuels" to radiation efficiency. Determinations were made of the radiating power of naked flames. Finally, experiments were made on condensing stoves. The results of all these experiments are recorded in the present report.

Incidentally to the conduct of the experimental work, Mr. Smith has, with the sanction of the Committee, been in frequent communication with the makers of stoves who by interview or correspondence have obtained such information relating to gas-fires as could properly be given. He has also accepted invitations to visit gas-stove works, and in one case has addressed an audience of heads of departments and travellers.

Mr. Smith has also lectured to students in the University on methods of heat measurement and transmission, and each student has spent a week with him, in order to gain an insight into the methods employed in gas-fire testing.

The Committee desire to record their continued satisfaction with the skill and assiduity with which Mr. Smith has carried out his work.

(Signed) Arthur Smithells (*Chairman*).
John Bond.
William A. Bone.
J. H. Brearley.
Julius B. Cohen.
Charles Wood.

A Modification of the Mechanical Arrangements in the Method for Determining Radiant Heat.

By reference to the report of the Gas-Heating Research Committee for 1909, it will be seen that the Committee's method for determining radiant heat was divided into two parts:—

(1) That in which the radiometer was used for determining the number of calories of radiant heat falling on the face of the radiometer at a point 34·4 inches from the front of the stove.

(2) The second part consisted in taking thermopile readings over the surface of the hemisphere of 34·4 inches radius having its centre at the centre of the surface of the fuel.

The mechanical arrangements for adjusting the thermopile at the desired points on the surface of this hemisphere, and the methods by which the surface of the stove, the radiometer, and the thermopile were brought into correct relationship with one another, were cumbersome and open to variation. This necessitated the repetition of most experiments in order that a mean of a few determinations might be struck and a most reliable result obtained.

This difficulty has been overcome, and with the following arrangement of apparatus the repetition of an experiment under the same conditions has invariably given figures within less than 1 per cent. of one another.

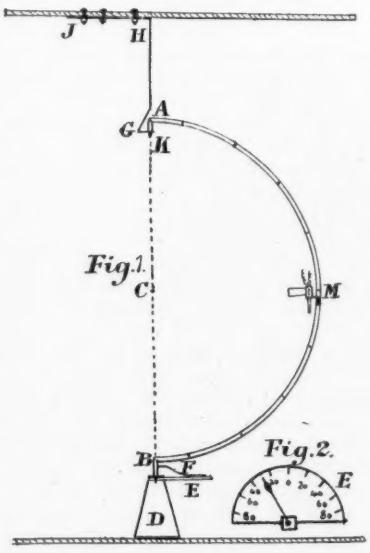

Fig. 1.

Fig. 2.

All the determinations of radiant heat given in this report have been obtained by means of this modification of the Committee's method. This arrangement is purely a simplification of the mounting of the thermopile in transferring it from one position to another on the surface of the hemisphere. It consists of a piece of $\frac{3}{4}$-inch round mild steel, bent in the form of a semi-circle of 36 inches radius, with two ends bent at right angles (K and B), turned to $\frac{1}{2}$-inch, to act as rests at G and D (fig. 1).

The semi-circular iron bar revolves round the axis K B. If the centre of the surface of the fuel of the stove is at C, then the centre thermopile reading will be at M, the centre of the thermopile being 34·4 inches from C. The radius of the semi-circular bar is 36 inches. The half-circumference

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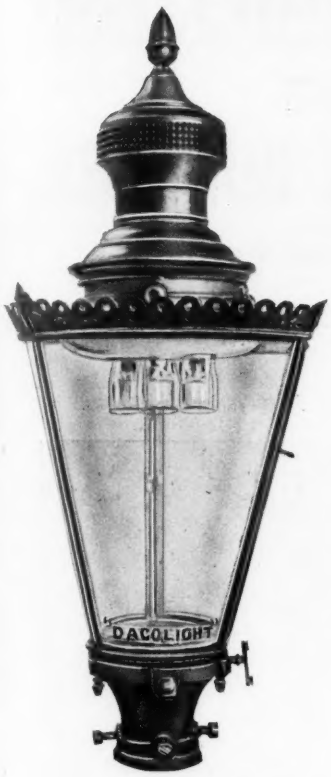

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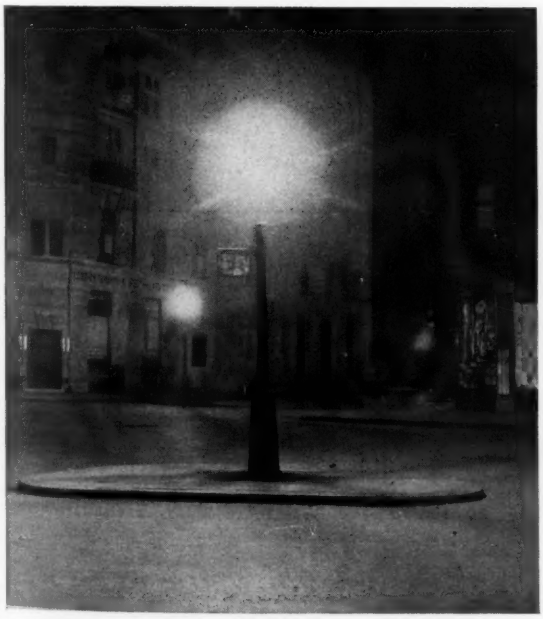

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will be 113½ inches. This, divided by nine—for the purpose of determining the points 20°, 40°, 60°, and 80° above and below the centre reading, as described fully in the 1909 report—makes each division 12½ inches. These should be marked off above and below C M (fig. 1).

The angles at which the horizontal readings should be taken—*i.e.*, to the right and left of the centre of the stove—are marked off on the board E (figs. 1 and 2). This rests rigid on the base D (fig. 1); and the pointer F (seen in section in fig. 1 and in plan in fig. 2) is attached to the revolving bar at B (fig. 1), and marks off the angle required on E (fig. 2). The fittings J H G (fig. 1) are made of 2-inch by ¼-inch mild steel, as is also the plate surrounding the base-box D. These may be adapted to the conditions under which the apparatus is used. This modification reduces considerably the time which the determination occupies.

The Determination of the Efficiencies of Various Makes and Types of Stoves.

With a view to making an examination into the principles underlying the efficient working of the open gas-fire, a number of makers were invited to lend certain of their stoves to the Committee; and these were each put through a series of tests and their results compared. The working of the stoves themselves was also varied until the greatest efficiency was attained. In one or two instances it was found that stoves, after being adjusted to suit the conditions under which they were tested, gave 4 or 5 per cent. better efficiency than when used as they were forwarded from the makers. It is always expected by the makers that stoves will be adjusted afresh after installation, but this is frequently neglected.

In the Appendix will be found a table containing the results of the experiments made on the various types of stove. Where flue-heat loss is recorded, it is the result of a separate experiment. During radiation determinations, the temperature of the room was quite normal—ranging from 15°-18° C. But during the flue-heat loss experiments, the door of the room was closed; and this accounted for the high temperatures shown in Column L.

All the radiation determinations were made with the radiometer-thermopile apparatus, as described in the 1909 report, with the modification described in this report. The modified form gave extremely consistent results, and showed that the older form tended to give low results.

Gas volumes have all been reduced to 60° Fahr., 30 inches of mercury pressure, and wet gas, although in actual working readings were taken in millimetres and degrees Centigrade, and calculated to 0° C. 760 m.m. dry.

As the method of making these experiments is described substantially in the 1909 report, no useful object will be served in repeating the account here.

By reference to the table in the Appendix, most of the details of the various stoves will be found; but a short paragraph describing each stove more fully, and also giving a few notes on the stove as a whole, will no doubt add to the value of the experiments.

Experiment No. 1.—In construction, this stove is of very plain design. The "fuels" are columnar, 7 inches high and slightly wider up their centre than most other fuels. They are almost cylindrical and regular in shape. This stove would have given a large percentage radiation if either the fuel had been narrower or the flames wider. The gas and air adjustment was good and convenient; but the flames were uneven in size. The amount of heat passing up the flue was very low, as arrangements were made in the top and back of the stove for taking much of the heat from the waste products without diverting them down the back of the stove. The fuel guard was replaced by a single bar of iron. In all experiments the gas and air were adjusted to give a flame showing an indistinct inner cone.

Experiment No. 2.—This was made under conditions almost identical with those of Experiment No. 1, the only difference being a higher calorific value of the gas. It will be seen that this is increased by about 3 per cent. If 30 to 40 per cent. of this increase in heat evolved be radiated, the total percentage of heat radiated will be increased by about 1 per cent. This is approximately the case within the experimental errors of the determinations. A rise in calorific value has caused a rise in the amount of heat radiated, the size of the flame remaining the same.

Experiment No. 3.—This stove was from a different maker. The "fuels" were longer, and not so regular as those used in Experiments Nos. 1 and 2. They were also less in diameter. The fire-brick back was of good construction and increased the radiation efficiency. No attempt appeared to have been made in the construction of the top of the stove to abstract heat from the waste hot products. This accounts for the high flue loss. The perforated iron casting directly above the burner prevented a large volume of cold air being pulled up through the fuels with the flames. This is a point sometimes overlooked. The gas and air adjustments were convenient and satisfactory. No fuel guard was used.

Experiments Nos. 4, 5, 6 were made with a stove having a convex front of fuel. It was fitted with a duplex burner and an iron fuel guard. Experiments Nos. 4 and 5 were similar in every respect, except that it will be seen that in No. 5 the increased size of flame, owing to a greater gas consumption, increased the radiation efficiency of the stove—although there was no corresponding increase in the numbers of calories being produced per hour. The stove was by the same maker as those used in Experiments Nos. 1 and 2. The special significance of the tests with the duplex burner is explained in another part of the report.

Experiment No. 7.—This is another maker's stove. The fuels were much shallower than is usual, and extremely irregular on the inner side. The construction of the fire-brick back added much to the value of the stove as a radiating appliance; the composition and conformation of the material intercepting and retaining heat that would otherwise have been convected. The construction of the body of the stove was such that the waste products were deprived of a larger amount of their heat than is usually the case. This stove had a sheet-iron back attached to it, and there were holes in the top of the stove from which much heat was convected. The gas and air adjustments were simple, adequate, and convenient.

Owing to the construction of the "fuels," slight changes in the position of the burner, or of the fuels themselves, would reduce the radiation efficiency 4 or 5 per cent. There was an iron grating in front of the "fuel." The width of this fire is greater than that of any other fire dealt with in this report. It will be noticed that the radiation efficiency of this stove is slightly higher than that of other stoves of a similar type. It may be taken that wide fires of a given type give higher radiation efficiencies than narrower ones. The mean temperature of the fire is increased; and although this increase be small, the increased amount of radiation is proportionately greater.

Experiment No. 8.—The stove had horizontal iron frets. Much has been said recently on the subject of the superiority of the old iron-fret stoves as radiating appliances. All the experiments and determinations that have been made in the course of this inquiry go to show that although the iron-fret stove is equal to the fire-clay type, still it is no better, and the advantages the latter have from the point of view of appearance and cleanliness—having no oxide dust—make it much to be preferred. Again, on first lighting the stove, there is more likelihood of the escape of carbon monoxide from the iron-fret stove than in the fire-clay "fuel" stove, owing to the much higher conductivity of the iron than that of fire-clay preventing the iron from warming up as quickly as the fire-clay.

Experiment No. 9.—The stove used had identically the same arrangement of horizontal iron frets, but the construction of the body of the stove was very different. Extending from the foot of the stove was a tray or fender projection, and at the top of the stove was a canopy acting as part of an arrangement for extracting the heat from the waste products of combustion. Both these projections cut off radiant heat which would otherwise have come into the room.

Experiment No. 10.—This stove was of massive construction, and the iron frets were in a vertical position in the form of iron sprays lying against the flames, one side of which touched the iron frets and the other side the small knobs of fire-bricks with which the whole of the back of the fire was studded. There were no gas and air adjustments in any of the iron-fret stoves. It would have been an advantage to have had them. The large upper body of this stove cut down the flue heat loss so much that it was with difficulty that a sufficient draught could be maintained up the main chimney.

Experiment No. 11.—The reflector stove consists of a number of long luminous flames, which burn horizontally inside the top of the stove. The heat and light from these flames are reflected by means of a curved copper reflector into the room.

Experiment No. 12.—The fire in this stove consisted of a number of perforated cylindrical tubes of fire-clay, each resting over a small non-luminous flame. The gas and air adjustment was elaborate, but easy to operate; but some difficulty was experienced in getting the correct adjustment to ensure the highest radiant efficiency with this stove.

Experiments Nos. 13 *to* 18 are experiments with stoves already reported on, but having fuels specially treated as described in another part of this report.

The Incandescent Mantle Stove.—This stove is of quite a new type, and is still in the experimental stage. It was submitted by the designer to the Gas Heating Research Committee for their examination. Its main principle is the utilizing of the heat passing from an incandescent gas light by absorbing it in the cast-iron framework of the body of the stove. At the same time air passing in at the foot of the burner is preheated by passing through the stove. The body of the stove was found to be very efficient in taking up the heat from the products. At the end of three hours the surface of the stove and the flue gases attained their maximum temperature, the latter being 81° C. Good combustion does not take place until a sufficient draught is set up in the flue, but was generally satisfactory at the end of 1½ hours.

The stove was covered with polished copper sheeting, which prevented radiation from the body of the stove; the heat passing from it as convected heat. The average flue heat loss at the end of three hours was 9·5 per cent. The heat radiated from the mantle and passing through the glass chimney was 21 per cent.; the remaining 69·5 per cent. being taken up by the stove and glass chimney, and passing away as convected heat. There were no arrangements for the reception of the water condensed in the stove.

The object in constructing the stove appeared to be to find a more efficient substitute for the so-called "gas-radiator."

General Remarks on the Above Tests.

In every case, two, three, and sometimes four, confirmatory experiments were made. The radiant heat efficiencies of different stoves of the same type are fairly constant, ranging from 37 to 43 per cent.

The stove dealt with in last year's report is included among the stoves reported on here. It will be remembered that the highest figure found for radiant heat efficiency was over 35 per cent. The new apparatus and careful attention to the various details outlined here relating to correct size of flame, its proper aëration, and a better adjustment of fuel, have increased the figure considerably.

There is great divergence in the figures in column K, showing flue-heat loss. This is entirely due to variations in the construction of the top of the stove and to the size, shape, and position of the outlet from the stove into the flue. No fan was used in any of these experiments for abstracting flue gases.

It would not be possible to state, even if it were permissible to do so, that any one make of stove stood out above all others as a type of what should be. There are a number of very good makes, each differing materially in details. Where one stove has an advantage in one respect, it falls short in another.

One stove having a high radiation efficiency might be improved by making arrangements for more heat to be extracted from the flue gases. Another, good in many respects, is worthy of a better design in the casting, or a better construction of burner enabling it to give even flames.

The aim of most makers in their design of gas and air adjustment is to make them as simple in construction as possible, and yet not to serve as a plaything for children and servants.

The "cheeks" and "chin" and canopy of some stoves seem to have had very little attention paid to their form and construction. Much can be done in the construction of the fire-brick back of the stove. Its shape should be designed to fit the fuel and keep it in place, as well as to intercept and deflect the hot products missed by the fuel. In composition, it should be as high a non-conductor of heat as possible, and yet act as a good radiator from its surface. Its object is not so much to radiate, however, as to conserve the heat to the "fuels."

In all probability the highest efficiency attainable with the present type of open fire, where the air of the room has free access to the front of the hot fuel, will be little more than 50 per cent.

There are four sources of heat-loss from the fuels:

(1) By radiation in all directions.
(2) By conduction to the air in contact with the front of the fuels.
(3) By conduction to the back and sides of the stove.
(4) By the convection of the waste products passing away from the top of the fuels.

The first of these is the one it is desired to increase. To do this, some or all of the other channels must be cut down. The waste products always leave the "fuel" at a slightly higher temperature than that of the top of the fuel; so that the higher the temperature of the fuel the greater the heat loss in the waste products. If the temperature of the main body of the fuel is raised, the loss by conduction to the air (2) and to the fire-brick back and body of the stove is increased. In many stoves in which the whole of the fuel is usually maintained incandescent, it would add to their efficiencies to increase the length of the "fuels;" for although the added fuel would not be incandescent, and would not radiate as much as the rest of the fuel, it would take up some of the heat of the waste products and conserve the heat of the "fuel" below it.

A better radiating material seems to be the only means by which the radiant efficiency of the stove might possibly be increased. But even with this the temperature of the material would be lower, owing to its having radiated more heat; and as the amount of radiation varies approximately as the fourth power of the temperature, it is very doubtful whether there would be any great increase in radiation efficiency by employing a better radiating material, the gas consumption remaining the same.

Although it appears that with the present type of stove the radiant efficiency will not be increased much beyond 50 per cent., there is no reason why the heat usually allowed to pass up the flue should not be utilized more than has been the case. It is, of course, not practicable to cool the products below a certain point, as a definite percentage of heat is necessary to maintain the flow of the products of combustion up the flue. This amount will vary with the height and construction of the flue.

Radiation from Bunsen and Luminous Flames.

The point of most importance in the study of the principles underlying the working of a gas-stove of the radiating type is the convenient and economical generation of the requisite amount of heat and the transference of the heat of combustion to the "radiating material" employed. In this connection, the question of the amount of heat the flame itself radiates is worthy of consideration. Very little has been done on this subject, the only references which had come to our notice previous to the few experiments reported on here being:

(1) That of a thesis by Robert Von Helmholtz (Beiblätter 14, p. 589, 1890), in which he finds that most hydrocarbon non-luminous flames radiate about 5 per cent. of their heat of combustion. He used flames of 6 m.m. diameter and 60 m.m. high.
(2) That mentioned in the discussion on a paper by Professor B. Hopkinson, "Explosions of Coal Gas and Air" (Proc. R.S.A. 77, p. 400, April, 1906), relating to some qualitative experiments of Professor H. L. Callendar on the loss by radiation in internal combustion engines.

These were summarized more fully in the discussion of a paper on "The Effect of Size on the Thermal Efficiency of Motors" (Proc. Inst. Aut. Eng., April, 1907), by Professor H. L. Callendar. Here it is stated that the heat radiated from an ordinary non-luminous bunsen flame might amount to 15 or 20 per cent. of the total heat of combustion, but that it depended on the duration of incandescence. It is further suggested that the larger the flame—whether due to increased gas consumption or to decrease in the air supply—the greater is the percentage radiation. This is explained as being due to the increase in the mean temperature of the flame.

These experiments have quite recently been repeated and confirmed by Professor Callendar and Mr. G. H. Nelson. They used a Mèker burner of 3 c.m. diameter, consuming gas at the rate of 11 cubic feet per hour.

The results of the following experiments will be seen to agree quite well with those obtained by Professor Callendar. No special apparatus was used for the determination, the radiometer described in last year's report and employed in

other work being adapted to this use. It was assumed that the flame radiated equally in all directions; and the method employed to measure the amount of radiation was to absorb the radiations from the flame falling on the 12-inch square surface of the radiometer at a distance of 6 inches. On the above assumption, calculating from the fact that the radiometer surface formed one side of an imaginary 12-inch cube, the number of calories radiated from the flame will be six times the radiometer value.

This method is subject to a number of minor inaccuracies; but for the purpose in view it was quite satisfactory. There were four sets of experiments, a Mèker burner being used in the first. This had a deep nickel grid, and was 3 c.m. in diameter. No estimation was made of the relative proportions of air and gas entering the burner. There were small cones at each perforation in the grating. These were about one millimetre in height. The flame was noiseless, steady, and quite conical. Its height was approximately 210 m.m. The gas consumption was measured by means of a standardized wet meter, account being taken of temperature and pressure at the meter.

The gas rate, reduced to 60° Fahr. and 30 inches of mercury, was 7·12 cubic feet per hour, and the calorific value 132·2 calories net. In this case, the flame radiated 14·9 per cent. of its heat. This was checked immediately afterwards, in order that similar conditions could be maintained, and the same result was obtained.

The second set of experiments were with a large type of Bunsen burner with a wire gauze taking the place of the nickel grid. The gas consumption was 8·9 cubic feet per hour, and the calorific value of the gas 137 calories net at 60° Fahr., 30 inches, wet. The width of the foot of the flame was 35 m.m., and at the middle 40 m.m. The mean height of the flame was 180 m.m., and the mean height of the inner cone was 70 m.m. This was distinct but not sharp, and the flame could be heard; but there was no spluttering, and it was not noisy. This was about the type of flame, in respect to its aëration, usually found in a gas-stove, although its volume was much greater. The mean of a number of experiments, which were practically constant in their results, showed that 15·2 per cent. of the heat was radiated from this type of flame.

The third and fourth sets of experiments were with the same burner as in the second; but in the third set the gas consumption was raised, and the proportion of air to gas in the mixture largely increased. The flame was noisy, and the inner cone distinct and sharp. The width of the flame at its widest part was 35 m.m. Its mean height was 160 m.m., and the mean height of the cone 60 m.m. For gas-stove practice, the flame was too well aërated. The gas consumption was 10·1 cubic feet per hour, and the calorific value 132·3 calories net at 60° Fahr., 30 inches, wet. The amount of heat radiated was 12·25 per cent.

In the fourth set of experiments, the amount of aëration was decreased, and, consequently, the size of the flame was increased. The inner cone was less distinct, and the flame was almost quiet. The gas consumption was 7·3 cubic feet per hour, and the calorific value 137·7 net at 60° Fahr., 30 inches, wet. Total heat radiated was 14·25 per cent.

It will be seen from these figures that variations in gas consumption—*i.e.*, the size or volume of the flame—vary considerably the radiation efficiency; Helmholtz, with a very much smaller flame, having found its efficiency to be of the order of 5 per cent. It can also be seen that variations in the amount of aëration of the flame varies the radiation efficiency—the less the aëration the greater the efficiency, until a point is reached when there is no pre-aëration at all, a luminous flame is obtained, and the radiation efficiency is considerably increased, as will be seen from subsequent experiments.

When the flames are surrounded with fire-clay fuel, the heat is being conserved to the flame, and in all probability the flames themselves in a gas-fire are radiating more than without the fire-clay fuels.

It is probably safe to suppose that these flames radiate at least 16 per cent. of their total energy.

Radiation from Luminous Flames.

These determinations were made in a similar way to those with the non-luminous flames. A Bray's slit batswing burner was used, having the usual steatite tip. In the first experiment, the gas consumption was 10·55 cubic feet per hour, and the calorific value 141·0 calories at 60° Fahr., 30 inches, wet. The percentage of heat radiated was 18·12 per cent. In the second experiment, with the same burner, the gas consumption was 10·1 cubic feet per hour, and the calorific value of the gas 132·3 calories per cubic foot of gas, measured at 60° Fahr., 30 inches, wet. The percentage of heat radiated was 18·15 per cent.

In the reflector stove reported on in another section of this report, it will be seen that the percentage of heat radiated is 26 per cent. This is probably due to a better conservation of the heat of the flame and to the flame having relatively a much larger luminous area. The actual amount of heat radiated from the flames in this stove is likely to be well over 30 per cent., as much of the radiant heat is absorbed by the fire-brick back and the copper reflector.

Effect on Radiation Efficiency of a Gas-Stove of Varying the Gas Consumption.

In most of the modern types of open gas-fires, the fuel is arranged so that a column of fire-clay fits directly over each of the flames of the burner. The conformation of the inside of each column of fuel is usually such that the outer edge of the contained flame will be in contact with it. The aim of most manufacturers of the modern shapes of fuels is to present as large a surface of fire-clay as possible to the flame, the fuel having a minimum capacity for heat.

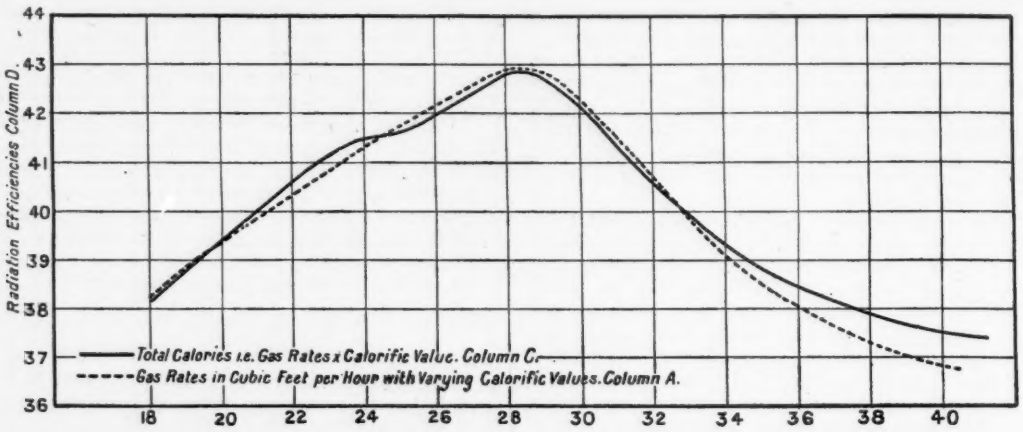
The larger the amount of combustion taking place while the reacting gases are in actual contact with the fuel, the higher will be the temperature of the fuel and the greater the percentage radiation attained, other conditions remaining the same. Should the column of fuel not fit the flame as well as it might—owing either to the shape of the fuel not conforming to the shape of the flame, or owing to the burner being out of centre with the fuel, or to the flame being too small, due either to an insufficient supply of gas or to a too large supply of air entering the burner—there must inevitably be much combustion taking place out of contact with the fire-clay, and the percentage radiation is consequently reduced.

Once it has been settled what type of flame is the most efficient from the point of view of its own radiation* and from the point of view of efficiency of combustion, then the shape of the flame can be studied under varying conditions, and the fuel adapted to it. Perhaps it will be well to consider at this point a few of the factors that determine the shape of the flame, apart from mechanical conditions connected with the construction of the outlet of the burner. It is well known that different gases singly burnt under exactly the same conditions vary in the shape of the flame they give. The well-aërated hydrogen flame is long and narrow, while the carbon monoxide flame, although only requiring the same volume of air for its complete combustion, is wider and shorter.

If the amount of these gases in coal gas varies to any considerable extent, the shape of the flame will be to this extent affected. It is also a well-known fact that although the composition of the gas may remain constant, or approximately so, and although all other conditions may remain the same, a variation in aëration of the burner will produce at the same time a change in the shape and size of the flame. A well-aërated flame is short compared with a non-luminous, but poorly aërated flame, which is long and cigar-shaped, the gas consumption having remained the same. The greater the supply of primary air, the smaller the flame.

The shape of the surrounding fuel itself is probably of as much importance in determining the shape of the flame as any other factor, especially when the flame is only partially aërated, as is usually the case in gas-stove practice. The air necessary for complete combustion of the gas has not as free a course to the flame when the flame is surrounded by fire-clay as when the flame is burning free in the atmosphere. As the fuel becomes heated up, the mixture of gas and air escaping from the burners, as well as the products of their combustion, will occupy twice to three times their original volume at atmospheric temperature, and the shape is still further affected. Nearly all these factors are determinable and controllable in the modern gas-fire; and the object of the following experiments was to determine to what extent the radiation efficiency of an open gas-fire is affected by variations in the gas consumption. The stove used was one of the most modern types, having long columnar fuels. The burner was one that ensures good mixing of gas and air, and gave even flames. The air and gas were regulated to

* The question of the radiation efficiency of the Bunsen flame is dealt with in another part of this report, as also is the question of shape and composition of the fuels.



give a quiet flame showing an inner cone clearly but not sharply defined. The gas consumption for the stove was stated by the maker to be about 27 cubic feet per hour. If stoves are used with the gas adjustments as sent out by the maker (this is usually the case), then the gas consumption will vary with the pressure of gas at the stove, and it will be a matter of chance whether the adjustment be right for the particular mean gas pressure maintained in any particular district.

In the accompanying table are given the results of five radiation determinations with the same stove working under the same conditions, except that in each the gas consumption was varied. In column A are found the gas rates, all reduced to 60° Fahr. and 30 inches of mercury, wet. In column B the calorific value of the gas used—the gas volume (1 cubic foot) being also reduced to 60° Fahr., 30 inches, wet. Column C is the product of the gas rate and calorific value, giving the total number of calories produced per hour in the stove; and column D shows the percentage of the heat that is radiated from the stove.

—	Gas Rate in Cubic Feet per Hour at 60° Fahr., 30 m.m. Mercury, Wet.	Calorific Value per Cubic Foot of Coal Gas at 60° Fahr., 30 m.m. Mercury, Wet.	Total Calories Evolved per Hour.	Percentage of Heat Radiated.
	A.	B.	C.	D.
1	19·35	141·4	2733	38·1
2	25·31	136·2	3445	41·1
3	26·42	141·7	3743	41·5
4	30·96	136·7	4230	42·8
5	37·22	142·2	5368	38·6

It can be seen that maximum radiation is reached when the gas consumption is 31 cubic feet per hour, and that if the consumption be increased or decreased, the radiant efficiency is decreased. This is still more marked in stoves where a more open type of fuel is used than that in the stove upon which these experiments are based. If this variation is expressed graphically with the percentage radiation values (column D) as ordinates and the gas rates per hour (column A) as abscissæ, a curve is obtained of some regularity (dotted line).

One would have thought perhaps at a first glance at the table that as the calorific values vary considerably between each experiment there would have been a greater regularity had column C been taken as abscissæ instead of column A. If this is plotted out, it will be found that this is not so, as the graph (the continuous line) so produced is very irregular compared with the gas-rate curve (the dotted line). This would lead one to the conclusion that the percentage radiation depends more on the shape of the flame than upon variations in the calorific value of the gas used, except in so far as the calorific value influences the size of the flame. In other words, if the gas rate be kept constant and the calorific value of the gas varies, the variation in radiation efficiency is less than if the total calories in the stove are kept constant and the gas rate varied. In the first case, the size of the flame remains approximately the same, and in the second place it varies with the gas consumption.

A point of immediate practical interest arising out of this question is found in connection with the use of "Duplex" burners. After a stove has been burning for some time in a room, it is frequently found that, when the desired temperature has been reached, it may be maintained by turning the gas off a little. It is noticed, however, that lower than a certain consumption—usually about two-thirds of the full consumption—the radiant heating efficiency falls with the consumption, owing to the shrinkage in the size of the flame causing it to burn completely out of contact with the fuel. To remedy this, the "Duplex" gas-burner has been introduced. This gives a series of seven to twelve flames, some of which—usually the side ones—may be turned off, leaving the middle flames burning. The gas consumption varies with the number of flames lighted. In this way the size of the remaining flames remain unchanged, and although the gas consumption is probably the same as if the flames had been turned down, the radiant efficiency is much higher.

The following three experiments show this to be the case:—

	Experiment.	Calorific Value 60° Fahr., 30 Inches, Wet.	Gas Rate 60° Fahr., 30 Inches, Wet.	Radiant Efficiency. Per Cent.
		A.	B.	C.
1	Seven burners full on. . .	136·1	18·01	37·73
2	Seven burners turned down .	137·4	9·62	30·74
3	Three middle burners full on	136·5	9·75	36·93

Care must be taken not to consider radiant efficiencies (column C) as amounts of radiant heat in considering these tables. By radiant or radiation efficiency is meant the percentage of the total heat evolved by the combustion of the gas in the stove that is experienced as radiant heat. The stove used in this instance was not one of the latest modern types, but nevertheless one that was quite satisfactory.

It will be seen from the table that when the seven burners are full on the radiant efficiency is a little higher than when only three are full on. This was to be expected, as the mean temperature of the incandescent surface of the "fuel" will be higher when seven burners are lighted and full on than the mean temperature of the surfaces of the three pieces of fuel within which three bunsens only are burning. One flame radiates to another and increases its temperature, while the end ones largely radiate into space.

Varying Composition of Fire-Clay Fuels.

So far very little attention has been paid to the subject of radiating materials used as "fuels" in an open gas-fire. Since the iron fret and asbestos fibre were replaced by fire-clay fuel the chief variations have been in the kind of fire-clay employed and in the shape of the fuel made from it. These two points are of the utmost importance, but there is a third point that is worthy of thorough investigation. The question must have occurred to everyone that if it is possible by means of a mixture of ceria and thoria of a certain composition to convert part of the energy of a non-luminous flame into light as seen in the light of an incandescent mantle—having a selective effect on the radiations—is it not possible to find a material which will convert the energy of the flame into radiations of longer vibrations, consisting chiefly of heat radiations and a smaller proportion of light?

It is a well-known fact that black bodies radiate heat much more than lighter coloured bodies. They also absorb more. This would lead one to conclude that it would be an advantage to make the "fuels" of some black material. This would, of course, reduce the amount of light radiated from the fire, as, being a better radiator of heat, the fuel would

be at a lower temperature than a worse radiator. This would detract from the brilliant appearance of the fire.

Iron "fuels" are known to be better radiators than fire-clay fuels if the temperature in each case is the same. If the same amount of heat is applied in either case about the same radiant efficiency is attained, as the iron fret radiates its heat at a much lower temperature than the fire-clay.

Then the question of heat conductivity of material enters in. The "fuels" are heated up in air and not in a vacuum, and the higher the conductivity the greater the loss of heat to the air. If a better radiating material were found, it would not be very difficult to improve the method of applying the heat to the material so as to raise its temperature to that of the usual fire-clay fuel.

There are two main courses of investigation open to those desiring to increase the radiant efficiency of a stove by modifications in the composition of the fuels. In the one, determination might be made of the effect of colour on the amount of heat radiated from the fuel, and in the other, the effect of varying constituents in the composition of the fuels bringing about selective radiation for heat in somewhat the same way as the thoria-ceria mixture causes selective radiation for light—apparently quite irrespective of the colour of the material.

During the course of the work in connection with the Gas Heating Research Committee, it was decided that some preliminary investigation should be made into this subject. Two gas-stove manufacturers generously lent the Committee sets of moulds for making their types of fuel. A supply of fire-clay was obtained from the Farnley Fire-Clay Company, and in a short time it was found possible, with care, to make the fuels of uniform shape and weight and perfectly satisfactory for testing for their relative values as radiating materials. Some difficulty was at first experienced in getting the pressed clay out of the moulds. After trying a number of lubricants, it was found that most thin oils were satisfactory for this purpose, but that the point of greatest importance was to have the moulds at the right temperature before use. This was found to be 25°-30° C. The pressed clay fuels were dried in air, the holes knocked out, and then heated in a muffle furnace at about 950° C.

All the fuels made were strong and durable. The first experiment had for its object the determination of the effect of varying porosities of fire-clay on the radiant efficiency of the fire-clay. The porosity of the fuel is regulated by the amount and grade of sawdust introduced into the fire-clay before it is moulded into fuel. Sometimes the sawdust is mixed with the clay while the clay is dry, but more often it is mechanically mixed (and sometimes hammered by hand by means of wooden mallets) with the clay after it is wet and ready for making up into fuels. Where convenient, it is better to mix the sawdust with the dry clay, as a better and more homogeneous material is obtained and more uniformly porous material is produced. There seems to be no fixed standard of porosity in many of the fuel works; a "few shovelfuls" of sawdust being mixed with almost any quantity of clay.

Two sets of fuels were made, having varying porosities. The sawdust used was white pine, over 90 per cent. of which would go through a $\frac{1}{8}$-inch sieve. In the first set, about 5 per cent. by weight of sawdust was introduced into the clay, and in the second set of fuels about 12 per cent. It is impossible to give the exact weights, and it is unnecessary, as the fire-clay was not perfectly dry, nor was the sawdust. But the 5 and 12 per cent. are relatively correct.

Both determinations of the radiant heat efficiency were done under the same conditions (see Experiments 14 and 15 in the table in the Appendix). From these figures it will be seen that with 5 per cent. of sawdust the radiant efficiency of the fuel was 44·7 per cent., while with more sawdust, and consequent greater porosity, the radiant efficiency was only 42·8 per cent. This would lead one to suppose that for this clay there is a maximum porosity which is useful as an aid to radiation. The value of a degree of porosity in the fire-clay lies in the fact that the porous clay requires less heat to get it to the same temperature than the less porous clay. The porous fuel also has a rough surface which appears to take up the heat from the flames better than a smooth surface.

It will be seen that the stove usually gave about 40 per cent. (Experiment No. 3) of radiant efficiency with the fire-clay sent by the makers. In this experiment, the gas consumption was slightly less than in Experiment No. 14. It might have been 1 per cent. higher had its gas consumption been the same.

Half-Fuels.

Comment has frequently been made that the front portion of the columns of fuel obstructs radiations from the back portion. This is obviously the case; but there are compensations. The outer surface of the fuel is not as hot as the inner surface, so that the inner surface of the back of the fuel must be radiating more than the outer surface of the front of the fuel. But the inner surface of the front of the fuel is itself at a very high temperature and radiating towards the back of the fuel, raising not only the temperature of the fuel but the temperature of the flame itself and causing them to radiate to a still higher degree.

Arising out of such comments it was decided to make a set of half-fuels, and test the radiant efficiency of the stove with them in exactly the same position as they would occupy had the complete fuel been used instead. It will be seen from Experiment 13A in the Appendix that instead of the radiant efficiency being increased by the removal of the front of the fuel, it is actually slightly decreased. Another experiment was made with the half-fuels slightly rearranged so as to catch the flames better than they did when in their usual place. The radiant efficiency increased to the figure obtained when whole fuels were used and the stove working under normal conditions—40·57 (Experiment 13).

This is most certainly a direction in which much advance might be made, as with one surface of fuels, as is partly got when half-fuels are used, and with a hotter flame such as that obtained from the coneless Mèker burner, it should be possible to obtain a surface of fire-clay fuel at a high temperature without the obstruction of the front portion of the present columnar fuel. These experiments show that, without special adaptation, an equal efficiency may be got without the front portion of the fuel.

Fuels of Varying Composition.

As it is hardly possible to distinguish between an increase in radiation brought about by a selective action of a constituent of the fuel and that produced by a variation in the colour, no attempt was made to do so, and the results obtained by varying the constituents of the fuels may have been effected by one or both of these causes. The Farnley fire-clay was used as a basis for all the fuels made up of special mixtures. The following is an analysis of Farnley fire-clay:—

	Per Cent.
Loss on ignition	10·0
Silica	60·0-62·0
Alumina	25·0-27·0
Ferric oxide (Fe_2O_3)	1·5
Lime	·2-·3
Magnesia	·2-·3
Alkali (K_2O)	·3-·6

The fire-clay was previously mixed with 5 per cent. of sawdust, as already described. The first mixture made was—

	Per Cent.	
Fire-clay	71·25	approximately
Sawdust	3·75	
Fe_2O_3	25·0	

The result of this experiment can be seen in Experiment No. 16 in the Appendix. This was made with the same stove as Experiment No. 8. This shows a distinct increase of 3 per cent. on the radiating efficiency of the stove. Other proportions of ferric oxide were not tried in this way; but this point will be referred to later.

In order that a wide range of fuels of differing composition might be tested in a shorter time, the process of making the mixture of fire-clay and other chemical constituents up into a full set of fuels for testing in the stove was dropped and a shorter and quicker method employed. For this purpose a small stove was moulded out of fire-clay, large enough to take one piece of fuel. This was dried and baked at 1000° C. A special burner was constructed for the stove and placed in position. The stove was mounted on a bench in a fixed position, and a thermopile was placed directly in front of it, 18 inches away. This was also fixed. The space between was covered in to protect the stove from draughts.

When a large series of fuels had been made of varying composition they were quickly placed in position, one after the other, and at the end of a quarter of an hour the number of millivolts shown on the galvanometer read off. By this means—the gas consumption and all other conditions being kept rigidly constant—the relative radiating value of each piece of fuel could be quickly determined, and should one piece prove very much better than the rest a set could be made, and a full test made for the radiation efficiency of the stove containing that type of fuel.

There were two methods of making the experimental types of fuel.

(I.) In the first, the necessary ingredients were mixed together before moulding and baking the fuels.

(II.) In the second, a piece of fuel, as supplied by the maker, was dipped in a solution of the salt of the metal the oxide of which it was desired to deposit on the surface of the fuel. After being dipped, the fuel was allowed to dry in air, and then baked for a few minutes at 950° C. in a muffle.

Under the first head, fuels of the following composition were made up—

		Per Cent.
(1.)	Farnley fire-clay	70
	Iron oxide (Fe_2O_3)	20
	Sawdust	10
(2.)	Farnley fire clay	85
	Iron oxide (Fe_2O_3)	10
	Sawdust	5
(3.)	Farnley fire-clay	87
	Iron oxide (Fe_2O_3)	9
	Sawdust	4

From each of these mixtures strong fuels were made; the greater the percentage of fire-clay present, the easier they were to make.

No. 1 was a dark red fuel; Nos. 2 and 3 being lighter, the colour depending on the amount of Fe_2O_3 present.

		Per Cent.
(4.)	Farnley fire-clay	81·4
	Magnesia	14·2
	Sawdust	4·4

This gave a white fuel, light in weight.

		Per Cent.
(5.)	Farnley fire-clay	93
	Ammonium chromate	2
	Sawdust	5

This mixture had to be dried more carefully, in order that the ammonia might be driven off without breaking the fuel. The fuel obtained was a sage green colour.

		Per Cent.
(6.)	Farnley fire-clay	79·8
	Iron oxide (Fe_2O_3)	14·0
	Ammonium chromate	2·0
	Sawdust	4·2

This mixture was made for the purpose of testing whether the presence of two metallic oxides would tend to bring about a selective radiation. The colour of the fuel was a reddish brown.

		Per Cent.
(7.)	Farnley fire-clay	71·0
	Manganese dioxide	25·0
	Sawdust	4·0

When baked this fuel was the dark brown colour of the manganous oxide.

		Per Cent.
(8.)	Farnley fire-clay	70·0
	Manganese dioxide (MnO_2)	24·0
	Ammonium chromate	2·0
	Sawdust	4·0
(9.)	Farnley fire-clay	86·0
	Kieselguhr	10·0
	Sawdust	4·0

This mixture gave a fuel of brown appearance. It was difficult to make with this amount of Kieselguhr present.

		Per Cent.
(10.)	Farnley fire-clay	81·4
	Alumina (Al_2O_3)	14·2
	Sawdust	4·4

The fuel from this mixture was white and light in weight.

Under the second method, the fuels were treated in the following way: Four ounces of the nitrate of the metal were dissolved in 400 c.c. of water, and the white fire-clay fuel put into the solution and allowed to remain until thoroughly impregnated with it. The fuel was then lifted out, drained, and slowly dried, after which it was gradually raised to a temperature of 950° C.; the nitrogen oxides being driven off much below that temperature, the oxide of the metal remaining.

Fuels were dipped in solutions of the nitrate of the following metals—

(11.) Cobalt giving a black fuel.

(12.) Nickel ,, ,, dirty brown fuel.

(13.) Copper ,, ,, black fuel.

(14.) Half fuels were also tested in this way, and the results showed that the amount of radiation given out from this type of fuel equalled that from the whole fuel.

(15 and 16.) The alumina and magnesia (10 and 4) mixtures were dipped in cobalt nitrate solution, and subsequently tested in the usual way.

(17.) A mixture of fire-clay, sawdust, and asbestos was also made into fuel and tested.

Fuels were also dipped in a solution of ammonium chromate of the same strength. The results obtained in millivolts as described above are as follows. The first figures are for a piece of fuel as sent out by the manufacturer.

Experiment.	Method.	Millivolts.
0	1	6·1
1	1	6·6
2	1	6·3
3	1	6·2
4	1	6·1
5	1	6·7
6	1	6·3
7	1	6·4
8	1	6·3
9	1	6·2
10	1	6·3
11	2	6·3
12	2	6·0
13	2	6·8
14	—	6·1
15	1–2	6·4
16	1–2	6·2
17	1	6·3

As a result of these experiments, immediately before drawing up this report full sets of fuels as supplied by the manufacturer were dipped in (1) copper nitrate solution, (2) ammonium chromate solution, and full stove tests were made with them. The result of these is that where the fuels were dipped in copper nitrate solution—giving a deposit of copper oxide after baking—the radiant efficiency proved to be 48·5 per cent. (Experiment No. 18 in the Appendix); and where the fuels had been dipped in ammonium chromate solution, the radiant efficiency was found to be 44·02 per cent. (Experiment No. 17). These figures clearly indicate that, with simple treatment, the radiant efficiency of the stove can be increased to an appreciable extent.

The oxides deposited on the fuel were found not only on the surface, but, before drying, evenly distributed through the fuel. While drying, the solution concentrated near the surface, where the fuel would be the driest. The oxides were found to a visible depth in the fire-clay. After extended use in the stoves, no wearing effect could be traced on the fuels. The change in appearance due to the use of a dark coloured fuel may militate against such a treatment of the fuel. That is for others to judge.

Condensing Stoves.

These stoves are often described as "gas-radiators" or "flueless" stoves, both of which names seem open to criticism. With the exception of a small number of types embodying open gas-fires from which the waste products are conducted to the main body of the "radiator," most of these stoves only give out a small quantity of radiant heat. The heating is almost wholly by convection, and this is the essential characteristic.

The air is heated by contact with the hot metal surface of the stove, and an upward current of this hot air draws continuously a fresh supply over the surface. The coils of the radiator are in effect a flue, and it is only in view of the fact that this flue is not usually connected with the room chimney that the apparatus can be called flueless. The flue has an important bearing on the whole design of the stove, as it depends almost entirely on its structure how far condensible products, such as water and sulphur acids, are removed from the gaseous combustion products before the waste gases pass out into the room.

The chief advantages claimed for this type of stove are:

(1) That the whole of the heat from the gas burnt, passing as it does directly into the room, is available for heating the room; whereas in ordinary stoves connected with a chimney quite 30 per cent. of the heat is lost.

(2) It is also claimed that as regards the more injurious combustion products, chiefly sulphur acids, the condensed water removes these, and only the comparatively harmless carbon dioxide passes into the room, and carbon monoxide, if formed at all, is only found in minute traces.

(3) Another advantage claimed for this form of stove is that, owing to its not requiring a chimney, it may be put in any position in the room or house.

The objections usually put forward are that the stoves are unfit for use in any but well-ventilated rooms, and that the better the ventilation the less is the amount of heat available for use in the room. The first objection is easily disposed of by the makers. Most of them refuse to supply such stoves for use anywhere but in halls or amply ventilated

rooms. Unfortunately, such stoves can still be found in small badly ventilated workshops, and under other conditions for which they were never intended.

There are several tests of this class of stove on record —*e.g.*, by Mr. H. Leicester Greville, Mr. F. R. Branston, Sir T. E. Thorpe, and Dr. Rideal, chiefly relating to the percentage of carbon dioxide and carbon monoxide in rooms where these stoves are used, and also some figures relating to the proportion of the condensed sulphur acids. The conclusions are that, under good conditions of ventilation, they need not be regarded as injurious—would, in fact, be less so than the overcrowding of human beings under the same conditions.

How much of the heat is actually usefully applied has not been discussed. This will vary so much with the amount of ventilation maintained, with the size of the room, and the amount of free space in the room, that any data obtained under this head would be of little practical value.

The stove that was used for these experiments was of simple construction, having an open gas-fire, from which the hot products were led through eight vertical tubes to the shallow reservoir provided for the condensed water at the base of the stove. There were six bunsen flames in the burner, which were controlled by a gas and air adjustment. The flames were surrounded by fire-clay fuel of the modern form, and the back of the fire was made of refractory brick. There was a projecting hood, which helped to direct the products of combustion up the four middle tubes.

The shallow trough was connected to the stove base by means of an air-tight water-sealed joint. The cooled combustion products from which much of the water they primarily contained had been condensed, then passed out into the room through a single hole 2 inches in diameter at the centre of the trough. A pan is usually placed on the floor under this hole, to catch the dripping that is sure to occur after a few hours' use and the trough has filled, and also to catch the water that is condensed from the escaping products on coming into the cooler atmosphere. The stove was 43 inches high, 30 inches wide, and 14·75 inches deep from front to back. The open fire measured 6 inches by 7½ inches, and was faced with a cast-iron guard.

In order that constant and normal results might be ensured during the course of the experiments, the stove was put in regular use for a period exceeding one month. A quarter-inch hole was bored in one side of the base of the stove through which distilled water might be run when washing out the condensed water, which was run off through a tap attached to the under-surface of the water-seal in the trough.

Before lighting the fire, any residual condensed water was run off through this tap. The tap was turned off and 300 c.c. of water were run into the trough in two portions; the first 150 c.c. being drained away, and the second remaining in the trough to act as a seal. This was done after each experiment. A large porcelain dish was placed below the flue outlet to catch the condensed water in excess of what the trough would hold. A thermometer was placed at the flue outlet with the bulb inside to take the temperature of the outlet products.

Another thermometer was then suspended 8 inches away from the surface of the stove, and was shielded from radiation from the stove by being surrounded by a cylindrical tube of asbestos 3 inches in diameter. From this, thermometer readings were taken of the temperature of the air coming in contact with the main body of the stove. The thermometer was sufficiently far away from the surface of the stove not to be affected by the hot air rising from it.

The experiments were conducted in a large room formerly used as a kitchen. There were five doors to the room, and it had one large window and an old-fashioned wide chimneyed fire-place. One door led upstairs; and this and another at the opposite side of the room were invariably kept open to ensure good ventilation. No door leading directly outside the house was kept open. The stove was placed in the centre of the room, and by means of thermometers distributed in different positions in the room a suitable distribution of the heat from the stove could be checked. The mean of the readings always closely approximated the reading of the thermometer suspended near the stove.

The temperature of the room was varied by varying the extent to which the doors were kept open; the door leading upstairs obviously being of most use for this purpose. The windows in the room upstairs were kept open to allow the hot air and products of combustion to escape. The gas consumption was determined in a similar way to that already described in these reports—account being taken of the temperature and pressure.

Sulphur Determination.—The *modus operandi* was as follows: The stove having been lighted for some time, and all necessary conditions for the particular experiment having been attained, the condensed water was quickly run off—the trough washed out with 150 c.c. of water, which was also run off, a further 150 c.c. was then added and left in the trough to act as a seal. During this operation, which lasted not more than two minutes, the stove was turned out, but immediately relighted at the end of the operation of washing out the condensed water. From this point the amount of gas consumed was determined.

At the end of the experiment, the stove was turned out and the gas consumption noted. The condensed water in the base of the stove was run into the porcelain dish which contained the drippings from the flue hole, and the trough was further washed out with 150 c.c. of distilled water; the washings being added to the main bulk. The amount of sulphur present in this liquid was determined in the usual way—*i.e.*, by preliminary oxidation by means of bromine water and subsequent precipitation of the sulphates by barium nitrate solution.

During the whole of the time the stove was lighted, a determination was proceeding of the total amount of sulphur present in the coal gas being used in the stove. A modified form of the Gas Referees' apparatus was used for this purpose. It consisted of a glass marble condenser followed by an air condenser, as in the Referees' apparatus; but to this was added a water-cooled condenser, to ensure more perfect condensation. There was no rubber about the apparatus, all the joints being of ground glass. This form of apparatus gave slightly (but consistently) higher results than the usual form. The results were checked by comparing them with those obtained by Mr. Edwards, the Chief Chemist at the Leeds Gas-Works.

The estimation of the sulphur present in the condensed water then proceeded in the usual way. The results of the experiments may be seen by reference to Table II. in the Appendix. It will be seen that eleven experiments are reported on. The sulphur (Column A) varied between 11·33 and 13·98 grains per 100 cubic feet of gas. The amount of sulphur condensed varied between 2·87 and 5·18 grains (Column B).

The experiments were not done in the order shown in the table, but are arranged in this way to better indicate how the percentage of sulphur condensed (column D) varies inversely as the temperature of the room (column E). When the room temperature is as high as 23°C., the percentage of sulphur condensed is 22·3. When the room temperature is reduced as low as 14°C., the percentage of sulphur condensed is increased to 38. At a normal temperature (say, 15-16°C.), the percentage condensed is about 30.

The temperatures of the flue gases were determined (Column F), and these indicate the mean temperature (30°C.) at which the flue gases enter the room. They do not vary with the temperature of the room as one might at first have expected. This is probably due to irregular draughts along the floor and to condensation and subsequent evaporation of water taking place on the bulb of the thermometer. This would cause the readings of the thermometer to be irregular. With the thermometer in the position described, it would hardly be otherwise. In columns C and H are found figures relating to the amount of water condensed in the stove and in the porcelain dish beneath the stove. At a first glance one would have thought that the percentage of water condensed would have varied in a similar way to the amount of sulphur condensed—*i.e.*, inversely as the change in temperature. From column H it will be seen that this is not the case, and, on a further examination of the point, the reason for this is evident.

In the condensation of the sulphur acids, the better the washing of the gases the larger the amount of sulphur acids that go into solution. The main part of the washing of the gases takes place on the inner sides of the tubes where water condenses and trickles down into the trough. In all probability, as far as the trough the percentage of water condensed does vary inversely as the temperature, so that the lower the temperature of the room the more water is condensed on the sides of the tubes and the better the washing of the gases. But what happens to the water that accumulates in the open porcelain dish at the foot of the stove? There may be anything up to a litre of water contained in it.

As the temperature of the room was varied for each experiment by varying the ventilation in the room, when the room was the coolest and the largest percentage of water was being condensed in the tubes of the stove the larger was the volume of air passing through the room, and specially over the open dish, as the main current of air would be an upward one from the stove. Consequently, the cooler the room the greater would be the evaporation of water from the dish beneath the stove. When it might have been expected that because the temperature of the room had decreased the amount of water would have increased, it was found that no regular variation occurred. Although the water in this dish contained much of the condensed acids, the evaporation of this water would hardly affect the percentage of sulphur condensed, as the acids would remain in the residual liquor.

Another point of interest that was touched on was the extent to which the iron of the stove was corroded or dissolved away by the products of combustion in the stove. From column J, it will be seen that, for every 100 cubic feet of gas burnt, the amount of iron dissolved and found in the condensed water as ferric oxide, both as a solid and in solution, varied between 7·47 and 5·33 grains. The inner surface of the tubes, after prolonged oxidation, tended to scale. Both these points have an important bearing on the life of the stove. Hygrometric measurements were taken over a few of the experiments; and it was found that, at normal temperatures, although there was more moisture actually present in the room while the stove was working, the degree of saturation slightly decreased.

Summary.

The amount of the sulphur acids condensed in the type of "radiator" under examination varies with the temperature of the room. At normal temperatures (60° Fahr.) this amounts to about 30 per cent., leaving 70 per cent. to pass into the atmosphere. There is a slight drying of the atmosphere, although the actual amount of water vapour present is largely increased. No trace of carbon monoxide was ever found in the products of combustion. The room was well ventilated; and under these conditions no ill-effects were experienced by those present, except during the first three experiments when the smallest amount of ventilation was maintained. The amount of iron dissolved from the inner surface of the "radiator" tubes varied from 7·47 to 5·33 grains per 100 cubic feet of gas burnt.

TABLE I.—APPENDIX.

	Description of Experiment.	Size of Radiating Surface. Inches.	Number of Flames in Each Burner.	Barometric Pressure in Inches of Mercury.	Pressure of Gas at the Meter in Inches of Water.	Gas Rate in Cubic Feet per Hour at 60° F. 30 Inches of Mercury, Wet.	Net Calorific Value of One Cubic Foot of Gas at 60° F. 30 Inches of Mercury, Wet.	Total Calories per Hour. (F×G.)	Percentage of Heat Radiated.	Percentage of Direct Convected Heat. 100−(I+K)	Percentage of Heat Lost to the Room and Passing up the Flue.	Temperature of the Room Air. °C.	Temperature of the Outside Air. °C.	Temperature of the Flue Air. °C.	Rise in Temperature of the Flue Air. °C.
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Open gas-fires, with fire-clay fuels	9× 7	7	30·07	1·44	19·14	136·2	2608	36·9	37·7	25·4	23·7	7·9	89·0	65·3
2		9× 7	7	29·94	1·5	19·11	140·6	2687	37·36	..	..	..	..	..	..
3		9× 9·5	7	29·50	1·34	20·44	127·9	2613	40·0	18·33	41·67	33·0	11·0	88·0	55·0
4	Do., with duplex burner	8× 9·5	7	29·61	1·12	16·78	136·1	2450	37·73	23·60	38·67	32·0	11·7	96·0	64·0
5		8× 9·5	7	29·22	1·39	19·24	128·3	2467	41·82	..	..	..	..	..	..
6		4× 9·5	3	29·28	1·12	9·62	137·4	1321	36·93	26·57	36·50	27·5	13·0	64·0	36·5
7	Open gas-fire, with fire-clay fuels	13× 6·5	8	29·13	3·21	30·96	136·7	4230	42·85	37·15	20·0	28·0	14·3	68·0	40·0
8	Horizontal iron-fret	7× 9·5	4	29·97	1·44	21·13	137·3	2899	41·06	..	..	..	..	..	..
9	Stoves	8×10	4	29·88	1·44	25·99	139·8	3637	35·0	35·05	29·95	34·0	12·3	116·0	82·0
10	Vertical iron-fret	10×12·5	11	29·68	1·01	29·12	139·0	4043	42·06	46·85	11 09	47·0	17·0	124·0	77·0
11	Reflector stove	12 inches	14	29·62	1·5	19·96	135·2	2699	26·06	..	..	..	..	..	..
12	Fire-clay fuels	9× 4·25	10	29·08	·8	16·64	137·0	2277	40·00	29·88	30·12	33·0	..	100·0	67·0
13	The same stove as used	9× 9·5	7	29·92	1·23	22·87	134·8	3081	40·57	..	..	..	..	..	..
13A	in Experiment No. 3, but	9× 9·5	7	29·67	2·41	23·93	128·6	3077	38·99	..	..	..	..	..	..
14	with varying forms of	,,	,,	30·01	1·34	21·45	132·5	2841	42·85	..	..	..	..	..	..
15	"fuels"	,,	,,	29·90	1·34	21·31	134·2	2859	44·73	..	..	..	..	..	..
16	The same stove as used in	13× 6·5	8	29·11	3·48	32·51	134·9	4381	45·86	..	..	..	..	..	..
17	Experiment 7, but with varying	,,	,,	29·93	2·89	27·13	137·6	3734	44·02	..	..	..	..	..	..
18	composition of "fuels"	,,	,,	29·82	2·99	27·17	137·7	3741	48·5	..	..	..	..	..	..

TABLE II.—APPENDIX.

Experiment.	Sulphur in 100 Cu. Ft. of Coal Gas, at 30 inches. 60° Ft.	Sulphur in 100 Cu. Ft. of Coal Gas, at 30 inches. Wet.	Total Water Condensed in C.C.	Percentage of S. Condensed.	Temperature of Room °C.	Temperatures of Outlet Gases.	Total Gas Burnt in Cu. Ft. at N.T.P.	Water in C.C. Condensed per 100 Cu. Ft. of Gas Burnt.	Iron (Fe.) Found in Condensed Water per 10 Cu. Ft. of Coal Gas Burnt.
									Grains.
1	10·54	2·98	..	22·3	23° C.	31° C.	..	..	..
2	11·28	2·68	2150	23·75	20° C.	32° C.	186·5	11·6	..
3	12 01	3·09	2350	26·33	19° C.	28° C.	227·0	10·3	..
4	12·36	3·49	3090	28·3	18° C.	34·5	271·0	13·6	7·47
5	13 04	3·95	1310	30·31	16 8° C.	34·3	108·0	12·1	5·95
6	10·56	3·21	2950	30·35	16·5° C.	31·0	214·0	13·8	5·33
7	12·22	4·07	1850	33·35	15° C.	29·0	117·0	15·5	6·9
8	11·34	3·78	2500	33·36	15° C.	32·0	208	12·0	..
9	12·39	4·31	2110	34·79	14·5° C.	29° C.	170	12·4	..
10	10·46	3·82	1600	37·36	14·0° C.	30° C.	97	16·4	..
11	12·71	4·83	2650	38·0	14·0	29° C.	213·3	12·49	..

Discussion.

The PRESIDENT said that Mr. Smith had given an excellent *précis* of the work of the Research Committee, and had proved the importance of the work done at the Leeds University. They had with them that morning several members of the Society of British Gas Industries to assist in the discussion; and he would ask Mr. Yates to open it.

Mr. SAMUEL GLOVER (St. Helens) said that, before the specialists commenced the discussion of this report, he should like to ask one or two questions while the Professor of the Leeds University was present. First, he wished to ask what was "fuel." He was very much surprised to find scientific men still using the word fuel to describe something which did not seem to him to come any longer under that heading. Even if, in the ignorance of gas engineers and stove makers in the past, they had improperly described as fuel what was really the radiating material put into a gas-fire, a better word should now be found for it. He thought Mr. Smith was going to keep to the fire-clay mixture in describing fuel as accepted by the Leeds University specialists; but later on he gave another radiating material—namely, cast iron. He (the speaker) was reminded of the old saying that "the proof of the pudding is in the eating;" and he thought that very largely the proof of gas-fires was in the heating. He could not agree with Mr. Smith's conclusions that cast iron occupied such a poor place in the life history of gas-fires. A beautiful radiating effect was obtained from cast iron. Notwithstanding the deposit of the oxide of iron which accumulated on the frets, cast iron was proved by long experience to be a very beautiful and most useful radiating material. The colour of the flame from a gas-fire using iron as the radiating material was much more acceptable to many people than the white flame which Mr. Smith seemed to be aiming at. In the report, an analysis was given of the Farnley fire-clay which he was very much afraid the Farnley Iron Company would not thank the Leeds University for giving in this form. Surely they would not allow it to go forward that this fire-clay, although tested with an admixture of 5 per cent. of sawdust, contained 10 per cent. of combustible material; and he should like to have a little more light on this subject. For the sake of their professional

character, he hoped the question would be cleared up whether fire-clay was a fuel or the gas which was consumed to heat it. He noticed with great pleasure the confidence that the gas-fire makers reposed in the Leeds University by actually lending them moulds.

Mr. H. James Yates (Birmingham) said only those who were associated with the class of work carried on by Mr. Smith and the Committee, could realize the large amount of labour and ingenuity which had been expended on these experiments. Speaking of experiments, he found himself in rather an awkward position, because he had naturally been carrying out many experiments in the same field, but circumstances prevented him saying almost anything with reference to them. He was very glad to hear what Mr. Smith had to say with regard to a simpler type of apparatus. As at present designed, it took an experienced chemist to work it; but he agreed with him that they were able to get a higher efficiency out of it as it was now used. Gas-fire adjustment was a very important thing to be considered; but he did not think the time would ever come when the manufacturer could adjust a fire in his works so as to be sure that it was going to act properly when it reached the customer. It must be borne in mind that the gas-fire of to-day was becoming a more scientific apparatus than it ever was before, and that it must be adjusted *in situ* by a competent man to suit local conditions. One could not expect an ordinary gas-fitter with the ordinary training to adjust a delicate piece of apparatus such as a gas-fire if the best results were to be got out of it. The report dealt with the question of the value of the flue heat, and suggested that more use might be made of it; in other words, that they might get more convected heat out of the stove. But there he must disagree with the author. For years past, he had been doing his utmost to eliminate all the convected heat he possibly could in stoves used for ordinary living apartments; and he was quite sure the reason why gas-fires had been in such disrepute was owing to the large amount of convected heat and the small amount of radiant heat which they gave off. He was very sensitive to these two forms of heat; and he had tried experiments on his friends as well. Speaking for himself, he could not sit in an ordinary living-room where the heat was convected; but with radiant heat, he did not suffer any discomfort at all. As Mr. Smith said, with a wide fire one would get a proportionately greater amount of radiant heat; and this was the principle he had advocated for a long time. He believed the wide fire was the solution of the difficulty, and that in this way they would get a much greater amount of radiant heat, and do away with the objectionable form of convected heat. He was glad to say they had been able to exceed the results given by Mr. Smith in his report of radiant heat. Mr. Glover had just forestalled him in his criticism of the word "fuel." The man in the street thought that fuel was something to burn; and many people believed it was the gas that was spoken of. His firm had adopted a word which might not be acceptable to others. They spoke of it as the "radiant," because it was the material through which they obtained the radiant heat. A standard type of "radiant" was, in his opinion, impossible at present. Mr. Smith named varying forms—some giving better radiation than others; and he quite agreed that this was so. But he did not suppose anyone had reached finality; and therefore a standard type was quite impossible. He also agreed with what he said in reference to a fire being the most pleasing to the eye and not always the best for radiating heat. He had been much interested in the shell experiments mentioned, because a long time ago he had experimented in this direction, and had taken out several patents for half fuel. They secured much greater efficiency as regarded radiation; but to the eye it was not so pleasing, and as a commercial article it would not have sold. Coming to the question of the radiating material, he had experimented with nickel, copper, and combinations of various metals, and also various oxides of iron and a number of earths—ceria and thoria; and, seeing that the liability of iron to oxidization so seriously interfered with its otherwise high value as a radiating medium, he tried experiments with barffing the iron, and also of mixing the iron itself with other metals with a view to minimizing the oxidation. In some cases, the result did not show any advantage; but in others, there was an appreciable increase of radiation. Unfortunately, however, the practical difficulty was that the cost of materials prevented it becoming a commercial success; and besides, until the evolution of the present absolute method of determining the radiated energy, there were no authoritative means of convincing the public of such improved results as were obtained. His remarks with regard to fuel also applied to the brick. There, again, he did not think they could have any standard size or shape at present; and it must always be borne in mind that the brick and the radiant must be so made as to fit together. The one could not work without the other. One could not take a particular fuel, and drop it on to somebody else's brick, or *vice versâ*. It was necessary to have the fuel and the brick designed to work together. He was very much surprised at the large amount of ignorance still displayed with regard to the burner and the injector. As usually designed, burners only took the right quantum of air at one given pressure and consumption; whereas with a properly designed gas-burner, one would get an even flame and the correct proportion of air at all reasonable pressures and consumptions. He thought that if gas-fires were ever to become popular and regularly used, the burner must be constructed on this principle. It was a difficult problem, and he had got over it. Mr. Smith, speaking of the radiation of a bunsen flame, said the greater the aëration the less the radiation. The experiments of his firm rather tended to suggest that, provided one kept the envelope of the flame in contact with the fuel, the greater the aëration, the greater the radiation. He thought that this probably must have been Mr. Smith's experience also, seeing that he mentioned the Mèker gas-burner in connection with half-fuels. There was a diagram showing results; and as far as he could see, they were all with one stove using fire-clay fuel. If a better radiating material could be found, he believed the maximum radiation might be maintained over a greater range of consumption; in other words, the shape of the graph would become a truncated cone.

Mr. W. H. Y. Webber (London) said he did not propose to criticize this valuable report in its entirety; but he wished to draw attention to what appeared to him to be a very important question—the effect of gas pressure on the operation of the bunsen burner. Almost the first thing that struck him on looking at Table I. of the Appendix, was that there did not appear to have been any systematic regulation of the pressures of the gas burnt. They ran from 1·44 and 1·5, which were fairly even, down to 1·12, which was too low for any practical purpose. Then there was 1·39; and then it jumped up to 3·21, and down again to 1·44. In one case, it was as low as 1·01; and in the place where fire-clay fuel was tried, the pressure was absolutely only 0·8. He quite agreed with the remark made on the previous day by Mr. Abady, that they had hitherto taken the element of pressure in gas distribution too much for granted, and they had not sufficiently distinguished that to them really their pressure was their voltage. Whereas, in an electricity supply, it was necessary to maintain the voltage within very small variation indeed over the whole district supplied, because of the imperfection of the apparatus used, in their case they took rather too much liberty in this respect. There were very few gas supplying districts in this country where there was anything like a reasonable uniformity of pressure from the centre to the circumference and all over the area. In his opinion, until uniformity within reasonable range was arrived at, they were simply fumbling in the dark with the various lighting and heating burners, and all the rest of it. At the present time, they seemed to be hovering over a *desideratum* of about 20-10ths; and it was a very general experience that with a pressure of from 20-10ths to 25-10ths or thereabouts, not sinking anywhere below 18-10ths, there was not very much trouble with working either lighting or heating burners. But when one had the variations of pressure which were permitted even here in a matter of testing, from 8-10ths up to 3·21 inches, it was impossible to know where one really was. He also agreed with Mr. Abady that he expected in the future gas distribution would be carried on at much greater pressures than were now customary; and he (the speaker) ventured to suggest that one point to which the attention of research chemists might be fruitfully directed in the future would be, What was the possibility of increasing the radiant efficiency of a gas-fire by increasing the pressure at which the gas was consumed? They had arrived at this stage of knowledge as to the effect of pressure on the operation of the bunsen burner—that the higher the pressure the more efficient the burner. This was a safe generalization. The pressure he spoke of was, of course, the pressure behind the nipple. He quite agreed that when once the proper pressure was arrived at, it should be maintained as much as possible; and the bunsen burner was essentially one of those things that could not be turned up or

down either for lighting or heating—it must be full on or off. Let them consider what went on with an ordinary bunsen burner worked under different pressures. When it was at the lowest possible pressure, which was that of an ordinary inverted lighting burner—he meant the resulting pressure in the burner-tube—that pressure was apt to fall in the tube; and therefore the admission of air was apt to fall off too. The higher the pressure they had at their command at the nipple, the higher the proportion of primary air they could get into the bunsen tube. He did not want to complicate the matter by considering the action of the inverted burner. Broadly speaking, the higher the pressure the higher the proportion of primary air that they could command; and the higher the proportion of primary air they got in, the smaller the flame, because of the less secondary air they required. So they went on till they got to the pressures now used in high-pressure lighting, when the proportion of primary air was somewhere about 4·8 or 4·9 volumes to 1 volume of gas —nearly the total amount theoretically required to burn the gas. For the proper illumination of the mantle, he believed it had not been found desirable to go beyond this, probably because a bath of secondary air was desirable to complete the combustion on the surface of the mantle, where it did most good. It struck him that there was some guidance here; and if they were able to command, for the purpose of heating as well as for lighting, pressures of gas up to 2 lbs. or 3 lbs. per square inch—and he did not at all see why they should not—he wanted to know whether these experiments could not be directed to find out if there was anything to be got for heating purposes with a gas-fire in this respect. It was not perhaps an immediately practical question; but that was what this inquiry was for. One of the objections to this way of treating a bunsen burner for domestic heating purposes was undoubtedly the noise; but this was a technical objection which engineers and manufacturers existed to overcome, and no doubt it could be overcome. But it certainly seemed to him that as they were all turning their attention in the direction of largely increased pressures, they would all of them much like to know what they might expect if those pressures were ever made available for the ordinary gas-fire.

Mr. H. M. Thornton (London), having thanked the President and Council for the opportunity now afforded to manufacturers of attending the meeting, and learning all they could, and, on the other hand, imparting what they had learnt themselves by their own researches in this particular subject, said he thought that they might congratulate the Leeds Research Committee on having, at any rate, proceeded on lines which could only have the full approval, if he might say so, of the gas-stove makers at large. When one considered that they had not at their right hand, as it were, the facilities of manufacturers for the purpose of constructing, for instance, the various shapes of fuel and other things in connection with gas-stoves which manufacturers had, he thought the results obtained and shown in the report were particularly good. It was also very gratifying to know that the instruments used in preparing the report had become so accurate as to some extent form a standard for manufacturers themselves to work to, which was a very important matter. Turning to the report itself, the question of the adjustment of gas apparatus when leaving the works was a matter which he was glad to hear referred to by Mr. Yates in his opening remarks. It was, of course, a very desirable thing, if practicable, that manufacturers should test their articles, so that when they reached their destination they did not need readjustment. But they knew it was impossible, much as they tried to achieve so desirable an object. Mention was made in the report that the radiant efficiency obtained on this occasion from the testings taking place in Leeds had increased from 35 to approximately 42 per cent., which was something they could congratulate themselves upon. He must say, however, they were not satisfied that 42 per cent. was by any means the highest efficiency to be obtained; and they had shown a higher result by their own tests. Further on, it was noted that if the height was increased with some particular fuels, the radiant efficiency would be increased approximately 2 per cent. In the particulars the author gave in Table I., he noticed that the low height of fuels there apparently gave a very high efficiency; and he should like to ask whether the 2 per cent. higher efficiency referred to would be an increase on the efficiency shown in Table I. Mr. Smith stated that if this were done, the top of the fuel would be naturally less incandescent; therefore the question of appearance at once came in. Of course, it was a question whether the appearance should be sacrificed for a small percentage of efficiency. They were all anxious to obtain both ends—high efficiency and good appearance. But if they really had very high incandescence and only a very moderate decrease in efficiency, it was an open question whether this was not a better ideal to work to than the reverse. In his opinion, the most important part of the report was that which dealt with the shape of the fuel used, and the shape of the flame. There could be no question that the fuel must be in accordance with the shape of the flame; and the effect of any reduction in the pressure as affecting the flame must be considered. If the shape of the fuel was not in accordance with the shape of the flame, a lower efficiency must take place to a marked degree. Nothing had been said with regard to the arrangement of the brick; but in their own experiments they found that if an "air pad," as they called it, was placed between the fuel and the brick, they got a higher efficiency than if they used simply the ordinary brick without the pad. He would ask whether, having in view the fact that air had a much lower heat conductivity than fire-clay, the loss of heat by not having an air pad would be material. With regard to the question of half fuel, experiments had been made by themselves for a good many months past, and they had now come to the conclusion that it was not wise to proceed in this direction. He noticed that in the flue temperatures the difference ranged nearly 20 per cent.—one test showed 20 per cent. flow in the flue, as against 40 per cent. in another case; and he should be glad to have an explanation of this. They had a great deal to thank the Institution for in having commenced this very important research; and whatever the future might have in store in the same direction, and under the guidance of the Institution, there was, to his mind, no question that one of the things which wanted further consideration was the shape of fuel and the shape of flame as applied to it, and the effect of the different gases which might be used in various towns.

Mr. W. J. Liberty (London) said Mr. Webber, in dealing with pressures, seemed to have lost sight of the important question of cost. He spoke about getting for gas-stoves pressures which, though they might not approximately come up to those employed for public lighting, would be something like them. But, if he had looked at Appendix I., he would have found that where they had a pressure of 3·48 inches, they got a consumption of 32·51 cubic feet; and unless they took into consideration the question of consumption with the pressure, the liability would be that they would make their gas-stoves prohibitive. When they talked about getting (say) 2 lbs. or 3 lbs. pressure, which was equal to about 70 to 80 inches of water, it would simply mean that they would probably have all the gas-stoves thrown on their hands. While they had manufacturers present, he should like to hear something from them about increased consumption, and therefore increased cost of gas-stoves, at high pressures as compared with the small pressures now used. He could quite understand that when a man got up to 32 cubic feet per hour passing through his gas-stove, he would write to the company asking them to take it away, or send him a stove showing a smaller consumption. Pressure, no doubt, was important; but, if they were to get to anything like the pressure Mr. Webber foreshadowed, they would have to put throttle-valves on the services close to the stoves, to break-down both the pressure and the consumption.

Mr. A. P. Main (London) desired to associate himself very heartily with the remarks made by Mr. Thornton, in expressing the gratitude of the gas-stove makers for the opportunity afforded them of coming to the meeting and hearing Mr. Smith and being enabled to take part in the discussion. To those engaged in the manufacture of heating and cooking apparatus, the great value of the work of the Leeds University was in its suggestiveness. There were many things in a report such as the one before them with which the individual maker would not agree; but even in this case he would find most valuable suggestions in pursuing his own work of testing and improving. There was this further advantage in the work of the Leeds University, that rival manufacturers, like rival politicians, were objects of suspicion. It was inevitable that they should all be enthusiastic with regard to their own particular ideas; and very often this enthusiasm perhaps carried them beyond the strict limits of truth. It was an immense advantage to them all that they should have this impartial scientific investigation pursued, which acted as a continual check on the experience of individual manufacturers. After all, they had only one

object in view, and that was to arrive at the truth. They wanted to know what was best, and how that best was to be attained. He heartily thanked Mr. Smith for the most instructive and most suggestive investigation which had yet been made in connection with gas apparatus. Mr. Webber had referred to a very interesting problem which every gas-stove maker had no doubt investigated—viz., the question of pressure. There was no doubt whatever that with high pressure they could get wonderful results in the way of heating; but the gas-stove maker was in a difficulty in applying such pressure, even if he had it, to such an article as a gas-fire, because no one would sit in the room with a gas-fire where the gas was coming in at 20 or 30 inches of pressure; the noise would be intolerable. It had been suggested that they might be clever enough in the future to invent a type of burner that would overcome the vigorous combustion which would take place at such a pressure; but he was not very hopeful that they would ever be able to do anything of the kind. They all realized that while they got wonderful results when very high pressure was obtained in a gas-fire, yet the discomfort occasioned by the noise made its use at present quite out of question. He did not agree with Mr. Yates—but there, again, he must bow to the scientific authorities—that one would get better results in a wide fire. But he agreed with Mr. Smith that there was much more to be hoped for in the direction of utilizing higher fuel. These were the lines they had gone upon; and, after all, if the upper portion of the fuel was not quite incandescent, it seemed to him that in this way they got radiation and they got economy, which he could not understand how they could get in any other way. The references to the composition of fuel were most interesting to manufacturers, because they had all been working on these lines. For many years past they had been striving, with all the aid they could command, to get a fuel of a composition which would give better radiation. But they would notice that in the report a kind of damper was put on their enthusiasm in this direction, because it was pointed out that, "as the amount of radiation varies approximately as the fourth power of the temperature, it is doubtful whether there would be any great increase in radiation efficiency by employing better radiating material." He was glad to find that, in spite of this disheartening view of the subject taken by the Committee, they had persistently gone on; and he hoped they would continue to go on with the investigation into the very best forms of radiating material.

Mr. J. H. Brearley (Longwood) said this discussion was intensely interesting to him, seeing that he had been so closely connected with the problem for some seven or eight years. He should himself like to hear from the general body of members something more on the subject of gaseous heating than had been said yet. Personally, he had nothing but praise for the work of Mr. Smith. They had in him an extremely careful and accurate investigator; and he had done a great deal, as exemplified by the report, to bring them into closer contact with the real difficulties in connection with gas-fires. To his mind, the most important points were the one with which Mr. Thornton had dealt—namely, the material in its relation to the size of flame—and the one to which Mr. Webber referred—namely, pressure. In his own paper some four years ago, he laid it down as his belief that no gas-fire should be fixed at less pressure than 15-10ths. But now that they had proceeded further, he was quite sure they could increase that, and say no gas-fire should be fixed at less pressure than 20-10ths, if they wanted to get the best radiating efficiency. He was rather sceptical as to the utility of giving considerably higher pressures than 2 inches, for he had not seen a fire yet which could be worked at a much higher pressure without making a noise which would be absolutely unbearable. He was glad to hear Mr. Yates make the confession that he could not sit in a room where the heat of the stove was almost entirely convected, without having to leave it very soon. He hoped the members would remember this, and be very cautious as to what situations they fixed flueless heaters in. There were one or two points he should like to say something upon; but there was hardly time then, and he would take another opportunity of doing so. He was very glad to notice that Mr. Smith had got as high results from the material which they misnamed "fuel" as he had from iron frets. In his own paper, he placed the superiority of iron frets—with a method of measuring which was, of course, less accurate than Mr. Smith's—at about 5 per cent. To explain the apparent difference, there was, of course, Mr. Smith's more accurate method of testing, and there was also the improvement in fuel-fires. The term "fuel" had been called in question; and he must confess that four years ago he wanted to use another term. He thought of asbestos; and he turned to some of his friends in the hope that they might find a word which expressed the material they used. But he must confess he was unsuccessful. If any member could coin a word he would be glad. Someone had suggested "radiant;" but he did not know whether this would commend itself to general acceptance. He thought they wanted something better. As one who had always taken the greatest interest in the education of the outside employees—and he believed he was one of the pioneers in urging the better education of the distributing employees—he was glad to hear emphasis placed on the proper training of gas-fitters. He had been somewhat surprised during the remarks made to hear so little said as to the good work initiated by the Institution in conjunction with the City and Guilds Institute. He referred, of course, to the Examinations in Gas Supply. This had been a good beginning; and he hoped engineers throughout the country would realize from this report and the President's address that the education of the outside employees was of paramount importance. In the case of gas-fires, it was essential to success. He had long been of this opinion; and he was glad to hear one or two makers emphasize the point.

Mr. H. Kendrick (Stretford) desired to add his meed of thanks to Mr. Smith and the Research Committee for giving them a report which was a distinct advance on the one made last year, and which would, he thought, produce some practical results. There were one or two points on which he wanted to ask questions. First, had the test for efficiency been carried out on fires in which 6-inch fuel had been used with cross fuel over the top? This seemed to him a method in which there was less escape of heat up the chimney than with the long fuel of 9 inches. At all events, carrying out a few tests of his own, without the refinements and scientific accuracy of the Committee, he got better results with the short fuel, crossed on the top, than with the long fuel. It had been suggested that one method of reducing the loss and adding to the radiant efficiency might be by pre-heating the air supply to the burner. He did not know whether anyone had yet tried this; but it would be interesting to have some information on the point. One gentleman said that he had made experiments with half-fuels, and had abandoned them because they were not satisfactory. But it occurred to him while he was speaking that with a reduced flame, if the fuel was inclined at an angle, he might get almost equal results as with a full flame in the vertical fuel. If the half-fuel were inclined at the top, so that the flame would impinge on the whole length, one would get very good results indeed; whereas, if the fuel were vertical, the flame, having nothing to meet it, would stand out, and one would not get such a good result. Another point raised was as to the effect of turning down the burner, and the loss of efficiency; and also the use of the duplex burner. The duplex burner referred to was one which cut off the outside burners, and left the middle ones lighted. But there was another one on the market, in which they got the "hit-and-miss" principle. It did not look quite so well, and might not be so good a selling article. But in some few tests he had carried out he found, with Mr. Smith, that with only the burners in the middle lighted there was a slight decrease; but that with the hit-and-miss principle there was an actual increase in efficiency up to 16 per cent., as compared with the whole fire full on. This point should be taken into account by the manufacturers; and, in spite of the apparent lack of interest in consumers with fires of this description, they should endeavour to impress upon them that they would get better value for their money in this way. One question had been raised with regard to the increase in pressure; but the speaker had entirely overlooked the fact that he would not have to put any special reducing valve on the supply-pipe, but could reduce the pressure at the nipple.

Mr. F. W. Goodenough (London) thanked the Research Committee for the valuable work they were doing for those engaged in the supply of gas (because all improvements in efficiency led to an increased sale), and for the assistance they rendered in arriving at proper methods of testing. As the Committee, he said, could not, of course, publish the tests of various makers' apparatus for the general use of members, or had not so far been able to do so, buyers of apparatus must necessarily make their own tests, because, as Mr. Main had said, the makers did have a tendency to

put the best face on their own apparatus. Mr. Main probably, like Lord Justice Bowen, would say: "Conscious as we are of one another's shortcomings." He did not suppose he was referring to himself. More efficient gas-fires meant an enormous increase in business; and therefore the work of the Research Committee and the makers, which during the last few years had resulted in a great increase in efficiency, must mean largely increased business in the future. One point which struck him had already been mentioned. They could not expect makers to send out apparatus which would require no adjustment according to local conditions; and he wished to associate himself strongly with Mr. Brearley in emphasizing the necessity for the education of all stove-fitters. Not only had they to look to efficient installation, but to efficient adjustment afterwards. It was no use putting in good gas-fires, and leaving them there, and expecting them to remain in adjustment for an indefinite number of years. Periodical inspection and adjustment would necessarily be a condition of the work of the gas company in the future. One of the earliest men in the gas profession to recognize this fact was his own Chairman, Mr. Corbet Woodall, who emphasized the necessity for the adjustment of gas-stoves in use; and with regard to the education of the men who were to carry out the work of the installation and subsequent adjustment, he had been very keen for many years. The Gas-light and Coke Company had shops for the instruction of apprentices, so that they might train the boys up from the time they left school, and make efficient gas-fitters of them. This was due to the initiation of Mr. Woodall. The question of varying pressures might be largely dealt with by the fixing of governors on each individual fire supply. They made a practice now of fixing a governor to practically every gas-fire they put in, in order that they might be certain that the fire would always work efficiently. They asked the makers to adjust the stoves, before sending them out, to 20-10ths; but the question of governing the pressure at which the fire worked was a most important one.

Professor Arthur Smithells (Leeds) said he felt it his duty, as Chairman of the Committee, in the first place, to say, what he was sure would be felt by all his colleagues, that they were extremely gratified by the discussion which had taken place; and they were greatly encouraged by the warm and generous testimony which had been given to the usefulness of their labours by those who represented the industry. A great deal had been said which invited remark; and he was afraid that he could occupy their time a great deal longer than would be at all comfortable. He would therefore restrict himself to one or two observations. Let there be no mistake about the object of this inquiry. It was not the casual whim of a few scientific men to play scientifically with the gas-stove. The object of the inquiry was to improve the gas-stove, and to make it a more efficient means of consuming gas. Their objects were thoroughly and entirely—he might almost say exclusively—practical; and he could not understand why he was occasionally singled out (though he did not mind it) as a person who was somehow cherishing, behind all his professions, a desire to do something which was in the clouds. His aspirations were entirely towards working on the earth; and, if there was one title of which he was jealous, it was his claim to be a practical man. Having said this, he was tempted to say a word in reply to the allegation of neglect with reference to the use of the word "fuel." The fact was they were so practical that they were afraid of being pedantic; and, though they felt how inappropriate this term might seem to some, they thought it better to use it from fear of being thought to be spinning things too fine. But the word was put in inverted commas; and he believed that, after all, one could say a good deal for it. He had no doubt that Mr. Glover kept his carriage in a coach-house, but did not call it a coach; and it was very much the same sort of thing. Even in the last resort, he ventured to think there was a black material on the market passing by the name of coal which was not appreciably more combustible than this fuel. They had tried in this investigation to deal with the fundamental principles of the gas-stove, and to devise some accurate methods of determining the various physical quantities they had to measure. Then they proceeded one after the other to the features which required investigation; and Mr. Smith had given a very good summary of the progress of this research as far as it had gone. A member of the Committee pointed out at its last meeting what a splendid thing it would be now if they took all these points one by one, and made them the basis for the construction of a gas-stove "such as was never seen before." Another member, on general philosophical principles, thought they might not succeed in that way. It might be supposed that if he were to pick out the virtues of the individual members of the audience, and combine them in one man, they would have a paragon gas engineer. Not necessarily. One might have a collection of incompatible virtues. So their gas-stoves, if they included every point that had been investigated and made clear by Mr. Smith, might not be the thing they hoped for. But the real answer was this—that they could not do it. They thought they could do a great deal at the University of Leeds, and probably they could; but when it came to constructing a gas-stove, he did not think that was their business. It was the business of gas-stove makers, who must work on the principles laid down, and construct this ideal gas-stove of the future. They had some other important things to be dealt with; and Mr. Smith was proceeding with inquiries, the results of which would be indicated in due course. Personally, though he was disappointed that nothing greater had been discovered so far, he quite thought they had made distinct progress, and contributed useful information. It would have been very nice indeed, of course, to have hit upon a fuel which was comparable (say) with the Welsbach mantle—*i.e*, a fuel formed by the accidental combination of certain materials, which suddenly passed from darkness into light. This was the history of the Welsbach mantle—"a pure accident in its initiation." It would have been very pleasant if, in their mixing of fuels, they had hit on something of the kind; but they had not done so—not yet. What eventually might arise, no man could foretell; and he was not going to prophesy. He would not go even as far as Mr. Smith in prophesying the effect of other gaseous fuels when used in gas-stoves. There was still plenty of scope for inquiry. What he believed was the most important point of all still awaited investigation, and this was the hygienic aspect of the gas-stove. After all, that was the thing against which they had to contend—the prejudice that existed against the gas-stove from the hygienic standpoint. He said "prejudice," and he believed he was using the correct word; but he did not know. They continually thought of investigating this aspect of the question; and he believed it was not only the most important, but by far the most difficult. He almost shrank from undertaking it. It was not a question of chemical analysis pure and simple, or of physical measurement, or of doctor feeling the pulse or counting respirations. There was a great deal more than this in it. He believed it brought in real questions of psychology. There were some people who could "feel" when a black cat was in a room. But how they did it, he could not say. There were many who averred they could tell at once when there was any convected heat in a room. Those were the people who really prejudiced the extension of the gas-stove; but he believed that they were more common among the other sex. The previous night (a pure accident) he happened to have the remark made to him by a lady that she had the feeling of an iron band coming across her head when a gas-stove was lighted—in the next street. Those were matters that wanted investigation. Whatever might be the merits of the Committee, he did not feel at all confident that those gentlemen were capable of facing an inquiry of such a character and delicacy. But that authoritative information should be put forward on the subject of the hygiene of gas-stoves, he believed to be most important; and he was rather inclined to undertake the investigation single-handed. He should then be committing no one but himself; and he believed it was a case where a man must back his own opinion only. He did not feel at all confident that it would be possible to get six or seven people to unite in an opinion on this subject in the way they could unite on other more definite questions. The only other thing that he wished to say further was that if the results of their inquiry were of any value, it was owing to the assiduous labours, the ingenuity, and the boundless hopefulness of Mr. Smith.

The President, before calling on Mr. Smith to reply, said the splendid discussion that morning was a practical proof of the appreciation they all felt for the labours of Mr. Smith in this direction; and it was not needful for him to say a single word in addition to what had been said by Professor Smithells in the concluding portion of his remarks. He did, however, think there was one great thing which followed from the starting of this Research Committee at the Leeds University. He was thankful to say the example which was set there of scientifically investigating this matter had been followed up and copied to a very great extent by

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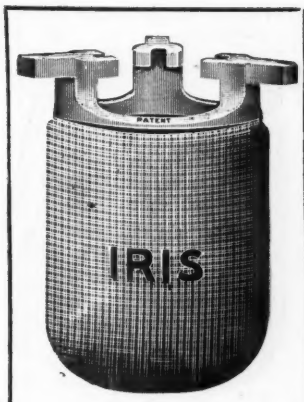

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the makers themselves, in employing scientific chemists at their works to go carefully into these matters. He thanked the gentlemen who had spoken from the practical side; and he apologized to one or two, such as Mr. Wilson and Mr. Davis, whom they would have liked to hear. But time was inexorable. He thanked the members of the Society of British Gas Industries for the kindly co-operation they had shown that morning. It was an indication of the great work which could be done by co-operation in these matters; and he hoped sincerely that in future they would be able to have even more occasions than in the past for working together on the lines indicated that morning.

Mr. SMITH, in reply, said, in answer to Mr. Glover about the analyses, that rather than trust to one analysis of his own in this connection, he got the average analysis as obtained by competent chemists at the Farnley Iron-Works. They gave it as it stood as being the average for all their fire-clay. The 10 per cent. probably contained a lot of water which was not driven off. Professor Smithells had referred to the question of "fuel." This point had been brought up many times; and it was decided to pander to the general habit. On the question of convected heat and radiated heat, and whether it was increased at the expense of the convected heat, it was not much use throwing away convected heat up the flue for the sake of saying that one had not got any. It might as well be used while it was there. With regard to the efficiency of half-fuels, the fuels tested in their case were put just in the position they would be in if the whole fuel was there. When the fuel was allowed to slightly rest on the flame, then a higher efficiency was obtained. It was not advisable to let them rise too much, because the flame went through the fuel, and one did not get any increased efficiency at all. The question of the brick at the back was most important. He tested two stoves of exactly the same make, and similar in every respect, with the exception that in one case there was one fire-clay at the back and in the other case another. The only difference was in the composition of the fire-clay; but there was 5 per cent. difference in the efficiency of the stove. The point of the question of the air pad spoken of by Mr. Thornton was easily seen. Not only when one had a definite air pad in a definite plan, but a more porous brick on the stove, and therefore more air pads in the pores, there was less conductivity in the back of the stove, and therefore better radiating efficiency. With reference to the effect of pressure, the object of having pressure was to take in more air, and to get a concentration of the heat at a given point. When one did so, it was too concentrated in many cases; and not only that, but there was no necessity to have a high pressure to get a larger volume of air in with the gas. It was quite easy to construct a burner—and the students at Leeds had been able to do it—so as to pull in volumes of air with the gas at quite a low pressure which were sufficient to all but completely combust the gas without any secondary air at all. It was a matter of construction. With regard to the question of increase from 35 to 42 per cent. in efficiency during last year, it came to this—that it was chiefly due to the improved construction of the back of the stove. He had tested another stove by the same maker, which gave an increased efficiency of 2 per cent. by increasing the height of the fuel. Pre-heating the gas and air was mentioned last year; and since then makers had tested the point, and he had tested it. It was found that, owing to the big increase in volume by heating the air before it entered the burner, one could not regulate the mixture sufficiently finely to justify the pre-heating of the air. With regard to informing each maker of the results of a test, he could only say that each maker, on being asked to lend the Committee a stove, was informed that the results of the testing of his stove, and his stove alone, would be given him, on condition that they were not going to be made use of in any way for advertising purposes. One maker wrote back and thanked him, but said that he would prefer not to have the results at all, if he could not use them for that purpose. Others, however, had received the results, and had secured what value they could from them.

GAS CALORIMETRY IN THE UNITED STATES.

By JOHN B. KLUMPP, of Philadelphia.

Gas calorimetry has been attracting as much attention in the United States during the last few years as it has in England and on the Continent. The extensive adoption of the incandescent gas-burner and the development of various industrial gas appliances has apparently created the feeling of the need, in some minds at least, of a standard of quality that will express more definitely the utility-value of the gas for such uses. It therefore occurred to the writer that a paper stating briefly the more important steps taken in administrative measures by government bodies, and a description of some work that has been done in gas calorimetry in the United States might be of interest to the British Institution of Gas Engineers.

The passing of Public Utility Laws in several of the American States has resulted in Public Service Commissions, whose general powers have been to supervise and regulate the Acts and work of the Public Utility Companies. In some cases the original laws specify definitely the quality and character of service, while in others the draughting of the regulatory clauses has been left to appointed Commissioners. Such actions have led to the passing of regulations controlling the manufacture and supply of gas and electricity; and as such requirements have in some instances been entirely a new step in governmental control, investigations by these Commissions have induced them to adopt the latest and most scientific regulations appertaining to the quality, pressure, and purity of gas. This has been particularly instanced by the Wisconsin Railroad Commission, which in its decision and order of July 24, 1908, adopted the heating value and omitted any regulation in regard to the illuminating value. Such specification is expressed in Rule 8 of its order as follows:

> "The Company furnishing gas which, within a one-mile radius from the distribution centre, gives a monthly average total heating value of not less than 600 B.Th.U., with a minimum which shall never fall below 550 B.Th.U., may be considered as giving adequate service as far as the heating value of the gas is concerned."

The decision also contains the following paragraph with reference to candle power, which so well described the situation that it will bear quoting here:

> "For the reasons previously outlined, it appears that the candle power standard which has been almost universally used in the past for gas measurements is of minor importance in this State. It is possible to secure a high candle power gas which has but a moderate heating value; and to require companies to maintain a double standard which shall insure the high heating value and a high candle power, would surround them with such restrictions that economy in manufacture might not be attained. And since but few consumers would be benefited by a candle power restriction, and with this number continually decreasing, no regulations as to candle power are prescribed at this time. It should be added, however, that with a 600 B.Th.U. heating standard, and in view of the conditions under which gas is being manufactured in this State, a fairly satisfactory illuminating value is insured. It is hardly possible to manufacture a coal gas of 600 B.Th.U. which shall not have a candle power from 12 to 16, or even more. The enrichment of a water gas up to 600 B.Th.U. will insure an even higher candle power."

These regulations were adopted after a general hearing by the Commission, to which were invited gas engineers and authorities from all over the country.

The State of Indiana, in 1909, passed an Act which compelled the gas supply of cities of the first class to be at least 600 B.Th.U. This State and Wisconsin are the only ones, so far, specifying the heating quality to be supplied.

This standard of 600 B.Th.U. is in the opinion of many American engineers too high to permit of gas being manufactured with the greatest economy to all concerned, or to permit the manufacture of straight coal gas under all conditions, without enrichment. The illuminating power specifications in the past throughout the United States have forced many of the coal gas companies to enrich their gas with cannel coal, oil, or benzol. While they have thereby increased the illuminating power of the gas, they have not proportionally increased the heating value to counteract for the increased cost of production; and in the face of this enrichment the present heating value determinations are being taken, which seemingly is placing a higher heating value upon the product than is desired, or such as would permit coal gas to be manufactured without enrichment. It is further hoped that such determinations will be made under the most economical conditions of manufacture, and such regulations passed as will specify a heating value that will enable gas of all kinds to be made and sold with the greatest of economy to all concerned.

It seems, however, that investigations should be undertaken while manufacturing gas to produce a uniform calorific value under these economic conditions, to determine what results could be obtained, before settling upon a calorific standard to be adopted.

Where the double standard for both illuminating and calorific value is imposed, a hardship is worked upon the supplying company, as the same conditions do not control either the manufacture or distribution of gas for each requirement, and a quality of gas must always be produced

to concur with the highest standard qualification. Such a standard usually limits the process of manufacture to be adopted, without regard to economic conditions of manufacture.

New York State, through its Commission, has regulated the illuminating quality of gas for some years in the past, and to-day specifies sixteen candle power for coal gas, eighteen candle power for mixed gas, and twenty candle power for carburetted water gas; and from this variation in figures it will appear that some attempt has been made to set the illuminating quality so as to obtain a fairly uniform heating value. The Commission of the Second District of the State has directed its engineers to make a series of readings on the gas of the various companies of the State; and the results were published in a report issued by Mr. H. C. Hazzard, which has been ably commented upon by the English publications. This report presents many interesting features, though apparent discrepancies; but it indicates that too few readings were made at each plant to attempt to formulate any rules governing the heating value of the gas as now supplied. This Commission is, therefore, now asking the co-operation of the gas companies to undertake investigations to determine whether it would not be politic or feasible to consider the quality of gas on some other basis besides its illuminating value.

Many of our State laws empower the various municipalities to pass ordinances as they may deem fit regulating the manufacture and supply of gas, and through this power the municipalities have passed regulations specifying the illuminating power, purity, and pressure, and, in some few instances, calorific value, without any particular method or consensus of action. The illuminating value called for is generally from 14 to 16 candle power for coal gas, and 18 to 25 candle power for carburetted water gas. The calorific specifications are included in only about ten of fifty large cities; and these cities require gas of a value of from 570 to 633 B.Th.U. The method of making readings is not specified; and in all but a single case the gross heating value is demanded.

Among the most interesting articles on the subject of gas calorimetry during the past year was the address of Dr. H. Bunte before the German Association of Gas and Water Engineers at Frankfort-on-the-Main, in June, 1909*. Here Dr. Bunte very strongly expressed his views for considering the calorific value of gas as being the basis of representing its general utility value for either heating or incandescent lighting purposes, and has expressed the opinion, after much research work, that the reading of the illuminating value of the gas is superfluous. He further states that it is not necessary to specify any particular heating value, or to limit the minimum; but he insists that the gas should have a limited variation from the selected heating value to be supplied.

Dr. H. Strache, Professor at the University of Vienna, in discussing Dr. Bunte's address, practically confirms his views; and with such evidence, it seems that the importance of this subject is not being over-estimated.† This opinion is not universally supported in the United States, owing to the still prevalent use of the open flame in many large cities; but it is being more thoroughly investigated from day to day, and is rapidly receiving the sanction of many gas engineers.

The total efficiency of the gas calorimeter having been questioned by some authorities, as to whether the results obtained from the readings of the calorimeter actually represented the total heat evolved in the combustion of the gas, it was thought that any tests that might prove its efficiency would be of a decided advantage. Dr. Immenkötter, of Berlin, in 1905, made some tests on a Junkers calorimeter, in which he determined the percentages of error due to various discrepancies in operation, and came to the conclusion that the calorimeter was an exceedingly efficient instrument.

The tests made by the Calorimetry Committee of the American Gas Institute‡ showed the efficiency in several types of calorimeters to be at least 99·5 per cent. These figures were determined by inserting an electric coil-heater in the calorimeter, in place of the gas-flame, and producing electrically a known quantity of heat, practically equal to that of the gas-flame, and then determining the amount of heat absorbed by the calorimeter in operating under conditions similar to those when the gas was being burned. With such confirming records and results, it seems reasonable to expect the gas-calorimeter in its present form is an instrument of sufficient precision to adopt for measuring the heating value of gas.

The writer was very much interested in the excellent discussion of this subject presented by Mr. J. H. Coste, in a paper read before the Society of Chemical Industry.* In this paper he speaks of four sources of error affecting results obtained from calorimeters of the water-flowing type. The first source of error seems to be due to the "heat lost or gained in the exit gases, as they are hotter or cooler than the inlet air." Our experience in America shows that this error is reduced to a minimum if the water supply is of the temperature of the surrounding air, as the products of combustion are thereby maintained at practically this same temperature.

Referring to the second source of error, "Heat lost or gained by condensation or evaporation of water during the passage of air through the calorimeter," the gas from the wet meter is apt to be saturated with water vapours, though not necessarily so. The air drawn in for combustion is at various percentages of humidity; while the products of combustion leave the calorimeter saturated. The error introduced by the moisture absorbed by the products is naturally a minimum, as the humidity of the air increases up to a certain point; and experiments made seem to indicate that on percentages of from 60 to 80 per cent., this error is so slight as to be negligible, particularly if the gas can be burned with a small excess of air. By having an adjustable damper in the flue discharging the products of combustion, and controlling this excess air, the errors affecting the results from this source can be made very small.

The third source, "Losses by radiation from the body of the calorimeter," are constants that depend upon the design and construction of the calorimeter itself; and the writer believes that the calorimeters now in use have reduced this to a minimum, and that such losses are practically negligible when the water temperature is at the temperature of the surrounding air.

The fourth source of error that Mr. Coste refers to is the assumption that a litre of water weighs one kilogramme. In America, this possible source of error has been eliminated by weighing the water, instead of measuring it volumetrically, so avoiding the necessity for any corrections due to expansion from increase in temperature, and obviating any discrepancy in volume due to entrained air.

The writer has commented on these remarks, as he wishes to emphasize the fact that the principal errors of calorific observations are due to the operation of the instrument, when the water for circulating purposes is used at temperatures other than that of the surrounding air.

Many essential points have been very ably brought out in Mr. Thomas Holgate's article on calorimetry, recently published in the "JOURNAL OF GAS LIGHTING;" and his general discussion of the various corrections to be made in determining the calorific value of the gas seems to indicate that these corrections would be at a minimum, providing the calorimeter could be so adjusted that the excess of air would be at a minimum, and the products of combustion could leave the calorimeter at temperatures approximating that of the inlet air and gas.† If these conditions are then maintained, the greatest variations then exist in the quantity of water vapours absorbed or precipitated from the products of combustion. He says: "It is impossible when the water is collected from the calorimeter to say how much of it is from the air supply and how much from the combustion." This quantity greatly affects the total condensate, and alters the reading of the net heating value, and is affected by the quantity of moisture in the air during operations.

In the test of the Boys calorimeter, which has a fixed air-passage space, Mr. Holgate seems to show that different gases, requiring varying air supplies, are not directly comparable, as the quantity of air apparently cannot be sufficiently controlled, necessitating, in some cases, excessive dilution; and for this purpose the writer is of the opinion that a calorimeter with an adjustable damper in the exhaust flue will give better satisfaction in determining the heating values for comparative purposes. Under these conditions, he has been able to operate with an excess of air as low as 16 per cent., and obtain perfect combustion; whereas the

* See "JOURNAL," for Sept. 28, 1909, p. 831.

† See "JOURNAL" for June 29, 1909, p. 968; also Sept. 28, p. 833.

‡ See "JOURNAL" for Dec. 29, 1908, p. 904; also Feb. 10, 1910, p. 295.

* See "JOURNAL" for Nov. 9, 1909, p. 407; also Dec. 21, 1909, p. 816.

† See "JOURNAL," Vol. CIX., p. 355 *et seq.*

excess air as shown in Mr. Holgate's paper is in the neighbourhood of 37 per cent.

Mr. Holgate's article is exceedingly complete and interesting, and, with Mr. Coste's paper, gives much valuable light on the subject of gas calorimetry. They both seem to dwell considerably on the net calorific value of the gas, to which, in the United States, very little attention is being paid, as it is there desired to express the calorific value of all gases in the gross heating value. The net heating value of carburetted water gas, it is found, runs from 5 to 7 per cent. lower than that of the gross heating value; and in coal gas, it runs from 6 to 10 per cent., depending upon the character of the gas.

The general tendency in the United States has been to supply gas of a higher illuminating power than has been supplied in the United Kingdom or on the Continent; and this has been due undoubtedly to the fact that a very large percentage of gas made in the United States has been carburetted water gas—60 to 70 per cent.—which in the past has averaged from 18 to 25 candle power, and in some cases even much higher. The tendency of late, however, has been to reduce this illuminating power, with the possible exception of two or three of the larger metropolitan cities. Therefore, where mixed gas is supplied, the illuminating power of the coal gas has been raised several candles. The heating value of the carburetted water-gas plants, on the average, has been as high as, if not higher than, the coal-gas plants, and, consequently, the mixed gas plants have been manufacturing a gas of a higher heating value.

The calorific value of coal gas is variable, and depends upon the grade of gas coal used, the yield per pound, and the general methods of manufacture. The larger coal-gas plants have been reducing their heating value by increasing their yield, and at the same time increasing their heating value by better and more scientific methods of treating the gas during its manufacture. The smaller plants have been increasing their heating value by having a decreased yield, but at the same time reducing their heating value by operating the plants less efficiently.

The calorific value of carburetted water gas manufactured has been very variable throughout all the plants of the United States, owing to the extreme variation in illuminating value demanded and carried, as has been shown by the report of the Engineers of the Public Service Commission, Second District, New York. It will be noticed, however, that the higher illuminating value produces a higher heating value, due to increased enrichment; and, analyzing further, it is seen that the heating value has been generally proportional to the quantity of enriching oil used, but at the same time is affected by the oil efficiency obtained, as the cracking-up of the hydrocarbons in the process of manufacture has changed the character of the illuminants of the gas.

Analyzing the data received from a number of plants, the writer has constructed an empirical formula that, while not entirely correct, in the majority of cases seems to confirm the results obtained in many calorific investigations. This formula is expressed as follows:

Calorific value (B.T.U.) = 310 + A × candle power, in which A = a constant due to oil efficiency.

A = 18 when candles per gallon = 4·25
17 ,, ,, ,, = 5·00
16 ,, ,, ,, = 5·75
15 ,, ,, ,, = 6·50
14 ,, ,, ,, = 7·23
13 ,, ,, ,, = 8·00

These figures are shown graphically in fig. 1. The heating value is expressed in B.Th.U., and the illuminating value in candles, as read with a No. 7 or 8 flat-flame burner, similar in construction to a Bray No. 7 slit union. In this formula, the oil efficiency is given in candles per imperial gallon, which increases the heating value by a certain constant—this constant supposing to represent the excess heating value per candle over and above that which would naturally be included in the blue gas before such enrichment was attempted.

These figures do not in all cases correspond, as the many methods of reading illuminating gas are more variable than the calorific determinations. For instance, the adoption of a burner that will produce one more candle in the same gas will mean an increase of from 5 to 10 B.Th.U. in the calculated heating value; but such a formula has enabled the writer to closely check the calorific power of carburetted water gas supplied by many plants in the United States.

Calorific Value from Gas Analysis.

A number of articles written on gas calorimetry have advocated the calculation of the heating value from the gas analysis. In a general way this might be done; but the writer doubts if either in coal gas or carburetted water gas it is safe to place too much dependence upon such calculations, more particularly where the gas contains illuminants, both fixed and unfixed, in any quantity. The simpler gases—such as hydrogen, carbon monoxide, methane, or ethane—may be easily determined and calculated; but the illuminating hydrocarbons are so complex in character that it is a matter of great difficulty to accurately determine their small percentage in volume sufficiently close to give their exact proportionate heating value to the gas. In the hands of the most experienced gas analysts, analyses can be made to give fairly comparative results, but not close enough to be used for giving calorific values for scientific or regulation purposes.

Essentials for Accuracy.

In American investigations to establish accurate and uniform methods of determining the heating value of a gas,

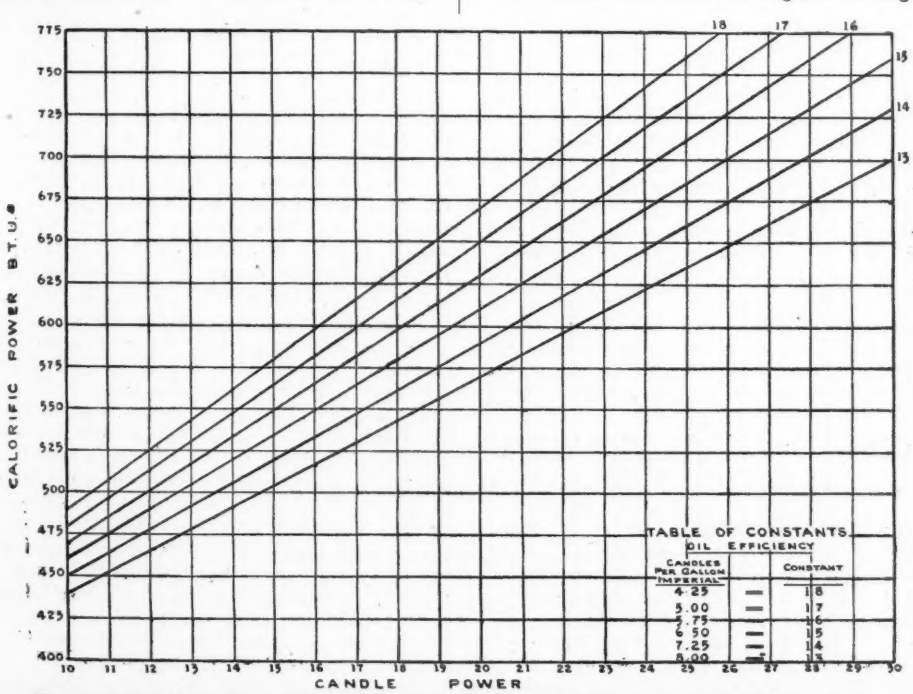

Fig. 1.—Heating Value Chart—Curve for Determining the Calorific Value of a Carburetted Water Gas from its Candle Power and Oil Efficiency—*i.e.*, Candles per Gallon.

it was found that the greatest essential to correct work was that the gas, air, and products of combustion should enter and leave the calorimeter at the same temperature, and that the temperature of the atmosphere surrounding the instrument; and in calorimeters of the water-heater type—as the Junkers, Simmance-Abady, Sargent, and Boys—to arrive at this condition, it was necessary to have the inlet water at the temperature of the room. The inlet water, in nearly all cases, jackets first the outgoing gases, or products of combustion, which naturally assume the same temperature. The gas in the meter and the air entering the calorimeter usually agree within a degree. This being the essential of comparative results, a series of experiments were made on the same gas, by simply supplying water of different temperatures to the calorimeter, and holding all other conditions as nearly as possible constant. A curve of the results, as well as a table of readings during the test, is shown in fig. 2.

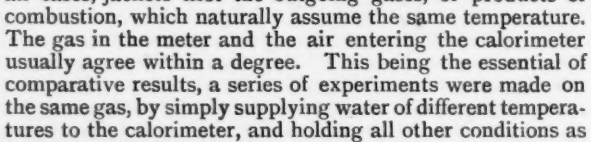

Fig. 2.—Curve Showing Variation of Calorific Value of Gas with Temperature of Water at Inlet of Junkers' Calorimeter.

English Units of Measurement.

Upon investigating the testing conditions in the United States, it was found that calorimeters were equipped with accessories of many varying kinds—meters measuring in litres, and meters measuring in cubic feet; Centigrade and Fahrenheit thermometers; graduations in cubic centimetres, in ounces, in quarts; and scales in pounds and ounces. The Committee on Calorimetry made recommendations to the American Gas Institute to have its companies adopt uniform methods of reading; in the first place, to greatly facilitate the work of making determinations secondly, to establish the adoption of uniform apparatus and operating directions.

The adoption of English units was recommended—that of expressing the heating value of the gas in "British thermal units," which is the natural product of the pound-degree; the measurement of the gas in cubic feet; the reading of all temperatures in Fahrenheit degrees; and the measurement of the water in pounds avoirdupois, preferably by weighing, although some graduations have been constructed to measure in pounds volumetrically. The writer is pleased to state that these recommendations are being generally followed; and reports from a number of companies seem to indicate that many of the bugbears of calorimetry have been eliminated by following these suggestions and other operating conditions which are recommended.

Gross v. Net Heating Value.

Many misunderstandings have arisen from the use of the words "gross" and "net," as applied to the heating value of a gas; and it has been the consensus of opinion of most of the operators of gas companies in the United States who have taken an interest in the subject and expressed their views, as well as many other investigators, that the gross or total value is the only proper and scientific method of expressing the heating value of a gas.

The American Gas Institute, at its annual meeting in New York, in 1908, passed the following as the definition of "Heating Value of Gas:"

> "The heating value of a gas is the total heating effect produced by the complete combustion of a unit of volume of the gas, measured at a temperature of 60° Fahr., and a pressure of 30 inches of mercury, with air of the same temperature and pressure; the products of combustion also being brought to this temperature. In America, the unit of volume is the cubic foot; and we recommend that the heating value be stated in terms of 'British thermal units' per cubic foot of gas."

The reasons for this action were manifold. The heating value of a coal or any other fuel is naturally expressed in its gross value, or includes the heat evolved by its complete combustion, including the latent heat of all water vapours formed. So, for comparative purposes alone, it was assumed the same would be advisable for gas. The gross heating value is the value which is obtained from a direct reading of the calorimeter, when the gas, air, and exhaust products from the calorimeter are at the same temperature; and the heat absorbed by the calorimeter is all the heat developed by the combustion of the gas. The result, under normal conditions of the atmosphere, is not absolutely exact, owing to the varying degrees of humidity of the atmosphere, and the entrained moisture in the gas and air entering the calorimeter not equalling exactly the entrained moisture leaving in the products of combustion. But, under ordinary conditions, this discrepancy is slight, and may be neglected; and under extraordinary conditions the error may be corrected.

The direct reading of the calorimeter gives a reading that is rather easily determined, and comparatively quickly; while the measurement of the condensate requires a much greater quantity of gas to be burned, and its collection and measurement are somewhat uncertain and difficult. Any variation in the temperature of the products of combustion affects the result to a greater degree than that of the gross value. Should the products of combustion leave at a temperature, for instance, as high as 130° Fahr., there would be no condensate; and this condition occurs in one type of calorimeter offered for sale on the American market.

Under such a condition, it must be observed that there is considerable loss in sensible heat of both the escaping gases and the vapours, as well as in the latent heat of the vapours.

The following specification illustrates the type of instruments and accessories recommended for American practice, with some instructions for operation.

Specification for Calorimeter Outfit.

The calorimeter should be of the water heater type, and one that transmits directly the heat evolved by the burning gas to a measured quantity of water; and at the present time it should be of a type as illustrated by the Junkers gas calorimeter—representing the best form of calorimeter obtainable, as shown by extended investigation.

The calorimeter should be accompanied by accessories that shall measure the gas in cubic feet, determine the quantity of water passed through the calorimeter in pounds avoirdupois, and indicate the temperatures of the air, gas, water, and exhaust products in Fahrenheit degrees.

The volume of the gas shall be corrected to a standard volume as expressed when measured at a temperature of 60° Fahr., and a barometric pressure of 30 inches of mercury; and the result of all calorific determinations shall be expressed in British thermal units, which is the natural product of the pound-degree.

The calorimeter should be so designed that the water will circulate freely, and be so distributed in all its heat-absorbing parts that

Junkers No. 872.

Readings.	1—4.	5—8.	9—12.	13—16.	17—20.	21—24.
Barometer	28·790	28·770	28·730	28·700	28·660	28·630
Temperature gas	69·400	68·350	67·800	67·700	68·100	68·150
Correction factor for gas volume	0·9354	0·9374	0·9374	0·9366	0·9344	0·9328
Humidity atmosphere, per cent.	62·000	62·000	62·000	75·000	88·000	100·000
Room temperature atmosphere	69·000	68·500	68·500	69·500	70·800	70·400
Exhaust temperature Products of Combustion	45·600	54·200	63·200	72·400	81·500	88·600
Gas rate, cub. ft. hr.	6·780	6·770	7 050	6·900	6·910	6·920
Gas consumed, cub. ft.	0·200	0·200	0·200	0·200	0·200	0·200
Water heated, pounds	7·499	7·428	7·251	7·306	7·295	7·255
Inlet temp., Fahr.	39·009	49·253	59·632	70·347	80·177	89·274
Outlet temp., Fahr.	54·491	64·532	75·150	85·732	95·466	104·246
Difference, Fahr.	15·482	15·279	15·518	15·385	15·289	14·972
B.Th.U.	620·200	608·200	601·200	600·200	596·800	582·100

Each result represents at least four distinct readings.

The barometer readings are low, as the place of experimentation was nearly 1000 feet above sea level.

before reaching the bulb of the outlet thermometer it will have maintained a uniform rise in temperature. To do this, the water should directly oppose, throughout the entire instrument, the flow of the burned gases. The rate of flow of water should be uniform, and controlled by a graduated cock on the inlet. This uniformity of flow should be controlled by the design of the calorimeter which should preferably have a weir-overflow on both the inlet and outlet, thereby obtaining a constant head of water at all times.

Care should be taken in the design to prevent air pockets forming in the water space of the calorimeter, and also to prevent the outlet thermometer from receiving any radiant heat direct from the combustion chamber.

To reduce radiation to a minimum, the exterior of the calorimeter should be constructed of bright polished metal, and air jacketed in all parts. It should be mounted on legs with sufficient spread to give stability, and with room enough underneath to allow the burner to be readily inserted, and observed after it is inserted.

The exhaust products should escape from a flue the area of which is controlled by an easily adjusted and graduated damper, as the heating value of the gas recorded is altered by varying the excess of air passing through the calorimeter —the least amount of excess to obtain complete combustion giving the highest heating value to the gas.

The thermometers that indicate the water temperature should preferably be placed on the same level. More recently-designed instruments show that this is possible, without any decrease in efficiency.

Meter.

The meter should be a wet meter registering one-tenth cubic foot per revolution of the drum; and, in practice, a complete revolution of the drum only should be taken into consideration. For convenience, the large dial should be graduated in one hundred equal parts. In addition to the large dial, there should be a smaller dial to register the number of revolutions of the large hand.

The meter should have an outside gauge glass, showing the water-level, with a fixed outside pointer, reading to the bottom of the meniscus. Considerable objection has been raised to the interior overflow as supplied on the German meters as not being easily checked or observable as to the water-level condition. The meter should be supplied with levelling screws, and should have securely fastened to the top two levelling tubes at right angles to each other.

The thermometer for measuring the temperature of the gas should be accurate within one degree, and should be in the meter top near the gas outlet. Many of the meters have an additional opening in the side to register the temperature of the water in the meter.

Regulator.

The use of gas-regulators is necessary for best work in calorimetry. One should be placed on the inlet of the meter, so that the gas will not be measured at a pressure over 15-10ths. Another regulator should be placed between the meter and the burner, to give absolutely uniform pressure to the gas as it is being consumed. A wet regulator as supplied with the Junkers instrument is very satisfactory for this purpose.

Burner.

After trying burners of several types, it seems as if the most suitable one is the long-tube bunsen with an adjustable air mixer, and having a spreader at the top to shorten the flame. Such a burner is preferable to the illuminating flame burner, as it is less likely to deposit carbon in the interior of the combustion chamber, and, by observing the flame, complete combustion can be controlled, and the flame will not smoke. The burner should be attached to the calorimeter so that it cannot be shifted, and so that the flame cannot impinge on any metal parts. By means of a reflecting mirror, the flame should be at all times observable.

Rate of Gas Flow.

In making a calorific determination, it certainly should not be necessary to specify the rate of flow, as in reading illuminating values; gases having a higher calorific value should be burned at a less rate than those having a lower calorific value, providing the capacity of the calorimeter is not exceeded. The rate of flow should be such that the products of combustion should not leave at a temperature exceeding the temperature of the air. The temperature of the water should be raised to such a degree that the possible error in thermometer readings would make the least discrepancy in the results. At the same time, the quantity of water passed through the instrument should be such that the error in weighing this quantity would make the least percentage of discrepancy.

Thermometers.

Accurate measurements of temperatures are among the most important adjuncts of correct calorimetry, especially the temperature of inlet and outlet water, and, consequently, the only very best thermometers should be used. It seems absurd to use telescopic reading glasses when the thermometer readings are in many instances half-a-degree in error. The adoption of the Fahrenheit scale, divided into tenths of a degree, enables divisions about half as great as with the adoption of the Centigrade scale. The thermometers adopted finally by the Institute Committee were carefully made and selected in pairs, reading from 60° to 110° Fahr., and having an auxiliary marking at the freezing point, 32°. These thermometers are usually correct within 1-10th of a degree, and are capable of being read much closer with the reading glass. Each thermometer is carefully gauged, and accompanied by a calibration or correction curve, showing its variation from the standard at all points on the scale. Thermometers with similar correction curves are used as pairs; so that the error will always be at a minimum.

Water Supply.

The temperature of the water best for all purposes has been shown to be that of the room; and it should be uniform, and not drawn from the ordinary house piping system, where the uneven consumption in other parts of the building will make it uneven in pressure and temperature. To obtain these conditions, it has been found advisable to supply the water to the calorimeter from an overhead tank, so situated that the water will acquire the room temperature and supply the water at an approximately uniform head. Such a tank, containing about forty gallons, will be sufficient to operate the calorimeter from one to two hours, under ordinary conditions of operating. Should continuous operation be desired, it is a simple matter to supply the tank with fresh water, regulating the temperature to the right degree by means of a small gas-heated coil. In this manner, the work can be carried on indefinitely.

Gas Piping and Tubing.

While the calorific value of a gas is not affected by the absorption of illuminants by rubber tubing to the same extent as is the illuminating value, it is advisable to connect up all the accessories with the least amount of rubber tubing possible. Metallic piping or tubing should be used to connect the meter with the source of gas supply, and, if convenient, likewise to connect the meter and regulator. This practice is recommended; but where rubber tubing is used it is advisable to see that it is thoroughly saturated by the gas before readings are taken. This precaution is probably more necessary in the higher-value illuminating gases in the United States than in the gas now generally supplied throughout the United Kingdom.

HUMIDITY.

The effect of humidity upon the calorific power of the gas is small, compared with its effect upon illuminating power, although the illuminating power effect is not generally noticed when reading against an open-flame standard, which will vary in power, in most cases proportionally to the gas-flame being measured. Corrections for humidity of atmosphere are not necessary in commercial calorimetry, but can be made, when desired, for more careful readings, especially when the air is so dry that much of the latent heat of the water vapours produced by combustion is carried off in the products of combustion. The humidity conditions may be obtained by means of the wet and dry bulb thermometers, having the wet bulb of the whirling type, or having the air impinging upon it from a small electric fan; or, better still, a more perfect instrument to use is the Assman psychrometer.

INSTALLATION OF THE CALORIMETER.

The operation of a calorimeter may be greatly facilitated by having it installed permanently at some point where it is to be continually in use. For this purpose, the writer suggests a cabinet that may be compared to a chemical laboratory hood. Such a cabinet is shown by the accompanying illustration (p. 828), and could be easily erected in

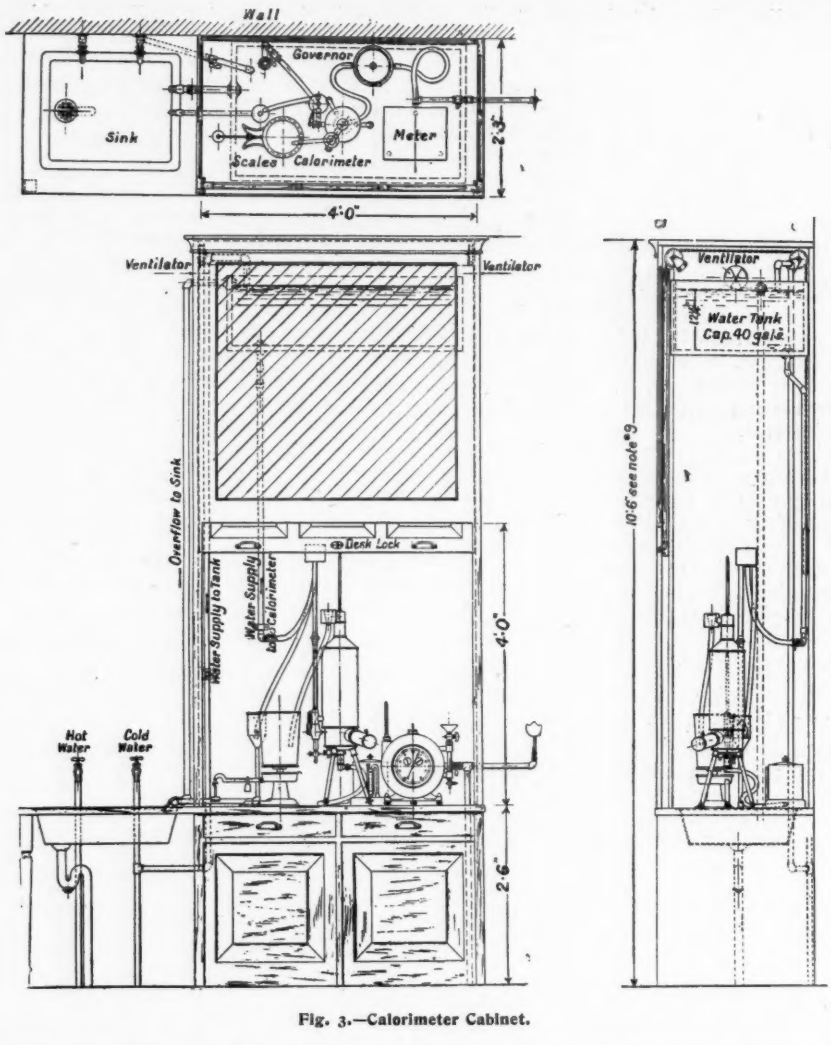

Fig. 3.—Calorimeter Cabinet.

any gas office or gas-works building. It is designed to be practically dust-proof, and to contain the calorimeter and all accessories in place ready for use. The thermometers need not be disturbed, nor the water drained from the instrument. The water-tank is shown above, and may be filled through the fixed piping; the water, when used and measured, passing to the waste piping through funnels, or being emptied directly in the sink. All cocks controlling the gas and water supply should be inside; and the cabinet should be kept closed and locked when not in use. Where there is not head-room enough for a vertical sliding door, horizontal folding doors may be conveniently substituted. The sides may be of glass, to permit the light to enter, as no burning jets, except the gas being measured, should be inside the cabinet. The cabinet should not be erected near heating appliances, nor in the direct rays of the sun.

The arrangement of the apparatus in the cabinet can be modified to suit the operator; but the illustration gives an idea of its general construction. The adoption of such an installation has greatly increased the efficiency of calorific readings at many plants by allowing the calorimeter to be ready for operation in a minimum of time, and permitting the work to be done with the least inconvenience.

Should the water supply be muddy or carry matter of any kind in suspension, it is advisable to instal a water filter between the supply and overhead tank. In several installations where the water was not good, it was found convenient to use distilled water, and to have a collecting tank in the base of the cabinet, catching all water from the calorimeter, and when the testing was completed to pump this same water back to the overhead tank.

Operating Directions.

Supposing the calorimeter to be erected in a cabinet with the accessories conveniently placed for operating, all the apparatus should be so arranged that the thermometers, gauges, and meter may be read easily and with the least movement of the observer's body. It is necessary to see that the gas-line to the meter is purged, and that a correct sample is being obtained of the gas to be measured; also that the gas-meter is level, and the water-line correct as indicated by the outside gauge glass, when there is no gas pressure on the meter.

If fresh water has been put in the meter, before testing, gas should be passed through it for several hours so as to thoroughly saturate the water.

All rubber tubing connecting the meter, regulator, and burner should be as short as possible, and should be saturated with gas.

The operator proceeds as follows: Turns on the gas and allows it to burn with the burner on the table of the cabinet; shuts the gas off at the burner cock and observes the hand of the meter for any indication of leakage; starts the water through the calorimeter at the rate of about 3 lbs. per minute; regulates the gas to burn at a rate of from 4 to 7 cubic feet per minute, as may be found by experiment to give the highest reading—admitting enough air through the bunsen regulator to just produce a faint luminous tip to the flame; inserts the burner in the calorimeter, and observes the flame again with a reflecting mirror, to see that it is correctly placed and burning properly.

The excess air passing through the calorimeter is controlled to some extent by the adjustable damper at the exhaust outlet; and it will be found that the best results are obtained when this excess is at a minimum. But in all cases the air must be sufficient to produce complete combustion. Experience with the calorimeters already tested has shown this position to be about one-fourth open. The quantity of water passed, and the rise in temperature of the water, seem to allow of some variation; but experience in America has seemed to indicate that the best results with a 600 B.Th.U. gas are obtained by permitting a rise of 15° Fahr., which would mean approximately 4 lbs. of water for each tenth of a cubic foot of gas burned.

There should always be a slight excess of water escaping for the inlet weir of the calorimeter, as such a condition

alone denotes a uniform head of water in the instrument. The outlet water also is running to waste until it is shifted to the measuring vessel.

Before making a test, the barometer, temperature of the air, temperature of the gas, and temperature of the products of combustion should be observed and recorded. If the water supply to the calorimeter is approximately that of the air surrounding the calorimeter, the temperature of the products of combustion should be within one or two degrees of this same temperature, and the results obtained should be as nearly correct as it is possible to get them with this type of instrument.

The gas should be allowed to burn in the calorimeter until a thermal balance is established. The water inlet being uniform, such a condition would mean the least change in the outlet water temperatures.

The test may be started by shifting the water from the calorimeter outlet to the measuring vessel as the hand on the gas-meter passes the zero point. Readings are thus made of the inlet and outlet water thermometers as rapidly as the observer is able to record them during the consumption of preferably two-tenths of a cubic foot of gas. At least ten readings of each thermometer should be made. Two-tenths of a cubic foot are suggested, as the errors of stopping and starting the water flow are reduced, and a better average of temperatures is obtained.

The water is then shifted from the measuring vessel to the waste, as the meter-hand passes the zero-mark the second time. The water is then weighed, and the amount is recorded in pounds and hundredths of a pound.

The heating of the gas is then obtained direct by multiplying the difference of the average of the inlet and outlet temperatures by the quantity of water passed in pounds, and dividing by two-tenths. This heating value is then corrected for gas of standard temperature and standard barometric pressure by dividing by the constant obtained from tables for the indicated temperature and pressure.

In weighing the water in metallic containers or vessels, it is advisable to weigh the container first when wet, inside, to avoid any discrepancies in consecutive tests. A safe method is to fill the container with water, emptying and shaking for about five seconds in an inverted position.

CALORIMETER READING

.....WORKS DATE.....

GAS

CALORIMETER TEST NO.

TEMPERATURE OF GAS BAROMETER

CORRECTION FACTOR F.

HUMIDITY

TEMPERATURE ATMOSPHERE

TEMPERATURE EXHAUST GAS

CONDENSATE PER CU. FT. GAS

TIME ONE REV. METER

GAS CONSUMED DURING TEST V.

WEIGHT WATER HEATED W.

WATER TEMPERATURES		BTU = $\frac{W(T^2-T^1)}{V \times F}$
INLET	OUTLET	
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
AVER.		
THERMOMETER CORRECTION		
	T_1	T_2
RISE IN TEMP.		B.T.U.=

REMARKS

Observer.

Fig. 4.—Form for Calorimeter Returns.

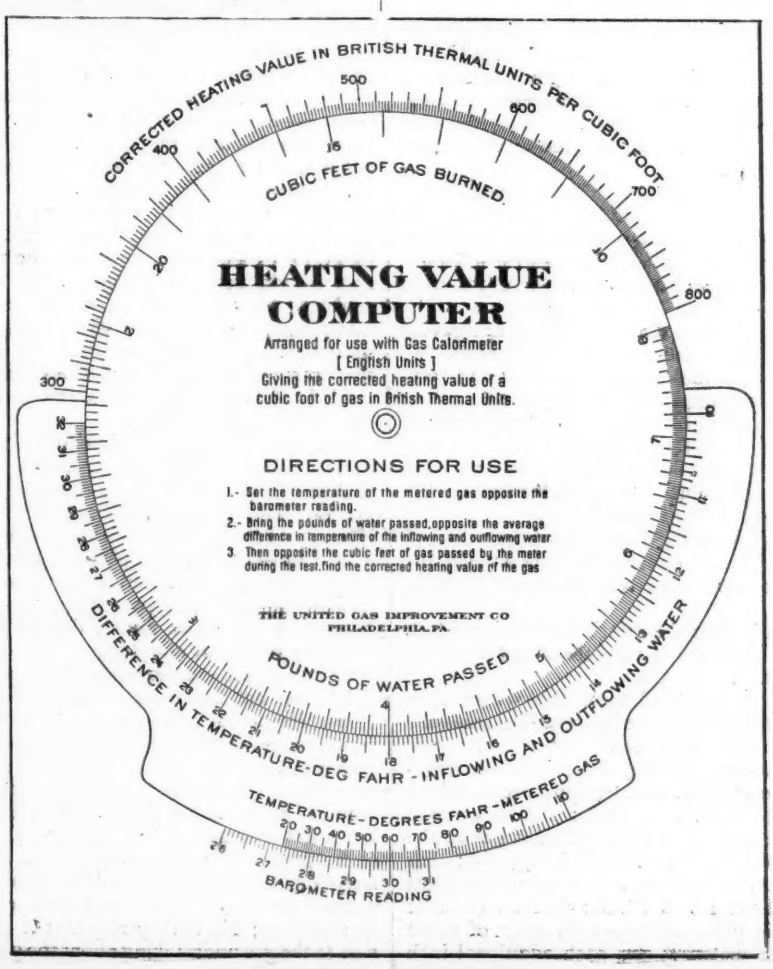
CORRECTED HEATING VALUE IN BRITISH THERMAL UNITS PER CUBIC FOOT
CUBIC FEET OF GAS BURNED
HEATING VALUE COMPUTER
Arranged for use with Gas Calorimeter
[English Units]
Giving the corrected heating value of a cubic foot of gas in British Thermal Units.
DIRECTIONS FOR USE
1.- Set the temperature of the metered gas opposite the barometer reading.
2.- Bring the pounds of water passed, opposite the average difference in temperature of the inflowing and outflowing water
3. Then opposite the cubic feet of gas passed by the meter during the test, find the corrected heating value of the gas
THE UNITED GAS IMPROVEMENT CO
PHILADELPHIA, PA.
POUNDS OF WATER PASSED
DIFFERENCE IN TEMPERATURE-DEG FAHR - INFLOWING AND OUTFLOWING WATER
TEMPERATURE - DEGREES FAHR - METERED GAS
BAROMETER READING

Fig. 5.—Heating Value Computer.

Under these conditions a second and third test may be made without altering any of the conditions, or stopping the flow of gas or water.

Calculating the Results.

When all readings are made in English units, the calculations are necessarily simple; but these readings should be recorded systematically to allow for checking results and making comparisons. A form (p. 829) is given which has been successfully used and found to meet all wants.

This form, it will be noted, calls for entry of all readings of temperature, humidity, and water measurement, whether they are used in the results or not, and is in card form for convenient filing. This form can be modified to suit local conditions.

The average of the water temperatures is determined and the correction error, if any, applied for each thermometer. For a determination of the net heating, the gas may be burned long enough to obtain sufficient condensate to determine the water vapours condensed, which represent only the excess over that required to saturate the products of combustion and excess air. This amount of condensate is variable with the same gas, depending upon the humidity of the atmosphere and the excess air admitted with the burning gas. The net heating value is then determined by subtracting the latent heat of this amount of condensate from the total heating value of the gas.

Use of Computer for Calculations.

The labour of making the calculations of heating value of a gas from the observations of a calorimeter may be lessened by the use of a slide-rule computer having divisions corresponding to the readings made with the calorimeter. This computer is designed to operate within limits of from 300 to 800 B.Th.U., and gives the corrected heating value of a cubic foot of gas, having the barometric pressure given, the temperature of the metered gas, the difference in temperature of the inlet and outlet water, and the pounds of water passed. Should a gas of lower or higher heating value than 300 to 800 B.Th.U. be measured, the computer can still be used by dividing or multiplying one or other factors in the computation.

General Observations.

It hardly seems necessary to mention, but in making recommendations to the operators throughout the United States who have taken up the subject of gas calorimetry, it has been found necessary to call their attention to some very important but simple precautions regarding the care and manipulation of the instrument; and those precautions might bear repeating here.

If the calorimeter be set up permanently, it should be installed in some dust-proof cabinet and provision should be made that it be not disturbed by anyone except the operator. If not set up permanently, when dismantled it should be carefully cleaned inside and out, and the thermometers removed and carefully put away.

Do not erect the calorimeter close to heating or lighting appliances whose radiant heat might affect the readings.

Do not forget to check the meter water-level and test-meter and all connections frequently for leakages.

Do not place the lighted burner in a calorimeter when the water is not running through the calorimeter.

Do not shut off the water while the gas is burning; and if the water be accidentally shut off, shut off the gas quickly so as to avoid breaking the thermometers.

Do not make the test with the inlet water more than 5° above or below the temperature of the air surrounding the calorimeter, unless due correction be made for this difference.

Do not move suddenly near the calorimeter during a test. Slight draughts thus caused will vary the outlet readings and might vitiate the test.

Do not fail to fill the overhead tank with water when through with the testing, so that the water will assume the room temperature for the next testing.

Do not fail to note, when operating under the above conditions, that an error of 0·1° Fahr. in water temperature means an error of about 4 B.Th.U. in the gas; that an error of 0·01 lb. of water, when burning 0·2 cubic foot of gas in the test, means an error of about 0·9 B.Th.U. in the gas; that an error of 1° Fahr. in the temperature of the metered gas means an error of about 1·8 B.Th.U.; that an error of 0·1 inch in barometric pressure means an error of about 2 B.Th.U.; that when metering gas, each additional inch of water pressure to which the gas is subjected means an error of 1·5 B.Th.U.; that any discrepancy (above 5° Fahr.) in the temperature of the inlet water from that of the air surrounding the calorimeter, injects an error into the calorific reading of the gas that increases greatly as this discrepancy increases, and a corresponding correction must be applied to give the true heating value of the gas.

Dr. Harold G. Colman (London) summarized the paper in the absence of the author.

Discussion.

Mr. Jacques Abady (London) said it occurred to him that the paper was really a conglomeration of points which were familiar to all experimentalists in this line. It did, however, add a little to their knowledge with reference to the regulations drawn up regarding calorimetry in America; and it was in this respect that a word of criticism might very fairly be passed. With reference to the change suggested, and he believed to a very great extent carried out, in the method of measurement, it appeared to him that the metric system lent itself very readily, and with quite sufficient accuracy, to the measurement of the rise in temperature in Centigrade degrees concurrently with the measurement of the water which was heated by the measured volume of gas in cubic centimetres, so as to be interchangeable with grammes. The American Committee recommended a departure in this respect, by going back to the Fahrenheit thermometer, and the weighing of water, just as Mr. Hartley did when he read a paper about calorimetry, which probably most of those present would not like to admit they were old enough to remember. He could confirm what Mr. Klumpp said with respect to the relative advantages of taking the gross and net readings. Certainly, a source of error, which might be considerable, would be removed, if the reductions from gross to net were cut out. To get the gross calorific power was a comparatively simple matter, although it involved a certain amount of care—a point which was not altogether recognized. But to get at the net result involved other things which were beyond the power of the observer to regulate. For instance, the temperature of the room and the percentage of humidity would have an appreciable effect on the amount of condensed moisture, besides which there was what he might call the apparatus error, in this respect—that the moisture clung to the wall of the apparatus, and did not flow regularly. In order to get over this, one had to take a very much longer measurement of the gas than would otherwise be necessary. On the other hand, there was this difficulty, that if the reduction from gross to net calorific power was neglected, they might have a gas which gave a very good gross calorific result, but was not equally efficient when reduced to net. It might contain a large percentage of hydrogen; and therefore he did not think, for experimental purposes, the net reading should be neglected for scientific purposes. If one wanted to see what one's gas was, the question of net was a problem to be gone into; but as regarded any official test which might be prescribed, it was a dangerous thing for any gas man to leave the testing of his gas in the hands of the ordinary person who carried out these official tests, and be willing to abide by the net results he produced.

Mr. Thomas Holgate (London) said he must express his thanks to the author for the kindly way in which he had spoken of the little work he (the speaker) had done in this matter. He was in general accord with the remarks of Mr. Klumpp as to the desirability of gas having its value stated in the gross form; but perhaps this conclusion ought to be supplemented by a fact which was made clear—by Mr. Coste's paper—that frequently errors of observation were present in the gross figure, due to the variations in the humidity of the air supply; and that these errors were corrected when the condensation figure was deducted; so that it left the net figure more correct than the gross figure. It was important to remember that in a good many tests which were detailed the gross figure was shown to be erroneous, and the condensation figure was also shown to be erroneous. But when one was deducted from the other, it gave an accurate net figure. This did not always apply; but it did in a great many instances. The relative merits of the gross and net results seemed to be a question very largely of what they expected the calorimeter to do. If they wanted it merely to tell them a certain thing, the gross would be sufficient; but if they required it to give exact information to the gas undertaking about the gas that passed through

it, both figures were needed. If they were correctly given, they would show a great deal as to the actual composition of the gas, and its value for illuminating, and especially for heating, purposes. Mr. Klumpp mentioned one point which it was perhaps worth while considering. He said that, by having a damper placed at the outlet of the calorimeter to control the outflow of the waste gas, a good deal of disparity might be eliminated. Probably this view was right; but the difficulty was to know how to apply a damper without making tests of the composition of the gas. In practice, it would be rather unworkable; and he should look at the matter slightly differently. Take a Boys calorimeter made for a fixed air supply. If this were used for something like a definite quantity of heat per hour, which could be easily ascertained by a preliminary test, they had sufficiently uniform conditions to get an accurate result, using the instrument with a certain rate of gas per hour, determined by its approximate calorific power. Their friends in Scotland had perforce to reduce the quantity of gas passed per hour, because they could not use so much, as the gas was of higher illuminating power; so that to get the power they had to reduce the air supply. Using a Boys calorimeter for a well-defined range of heat per hour, any source of error from an excess of air supply would be largely eliminated. This could easily be done; and it would meet the idea Mr. Klumpp had put forward, in a simpler manner. Another point on which stress was laid was undoubtedly of value—namely, that the supply of water to the calorimeter should be of the same temperature as the air of the room. There would be a ready acceptance of this view. The only difficulty would be whether, where the changes of temperature were rapid, one would be likely to get the proper temperature in water stored in a cistern in the room. Of course, such water would be much better than water supplied from a tap, in which case the temperature was usually considerably below that of the room. Fig. 2 and the table would be found to be useful; but they would have been very much more useful if the net figure had been given, and also an analysis of the gas, so that one could easily see whether these figures did correspond with the actual heating property of the gas. He was not aware that in this country anyone suggested that the official test should be made by first analyzing it. The only way he thought in which the analyses had been used was as a check on figures which were obviously incorrect as readings of the calorimeter. It could be shown beyond doubt that readings from calorimeters had been put forward which could not be substantiated when compared with the analyses. There was a great advantage in having the two sets of figures side by side, where accurate work was demanded. Mr. Klumpp used an argument relative to the net and gross value which did not seem to him very cogent. He said that, because coal was sold, or its value assessed, on the gross figure, this was a reason why they should not pay much attention to the net. He thought there was not much in this, because, as a matter of fact, as regarded the calorific power of solid fuel the relationship between the net and the gross was totally different—the amount to be deducted for the net in solid fuel was very small; and if it could be easily ascertained, it would be desirable to have it stated. If they gave the gross figure for coal, it was an inaccurate figure as to its actual evaporating power; and if they obtained the net figure, they would certainly be giving it more correctly.

Dr. W. B. Davidson (Birmingham) remarked that, in the first place, he should like to say a word about the error of the instrument. It was hardly worth while to trouble about the corrections for humidity and other things, provided the conditions were fairly constant. When using different calorimeters, they found a very slight error indeed in comparing the results. The other day he had occasion to test six instruments of four different types; and the error, in the case of five, was less than 1 in 300. When they had errors of less than ½ per cent., the instrument could be considered perfect. He might say, however, that calorimeters required careful supervision, because they were liable to get out of order. They sometimes found, through leakage or other causes, an error of 4 to 5 per cent., or even more; and where they had only one calorimeter in the laboratory, it was almost impossible to say whether there was an error involved or not. It was really very advisable in a testing-station to have duplicate instruments, and frequently to make duplicate tests. He had known a calorimeter to give too high a value, and had never been able to understand why. In one case, it was consistently 4 per cent. too high. He thought it must have been the lagging between the two thermometers that had given way. With regard to the question of weighing or measuring the water, he found that the most accurate way (having tried both) was to measure the water, using a 5-litre measure, but graduating the measure so as to give the proper weight—not to accept the graduation of the measure, but to correct it for temperature. This was simpler and more accurate than weighing the water. He was very fond of figures, but could not bear to see them given with over-exactness. He agreed that there was absolutely no necessity for having the thermometer graduated to Fahrenheit degrees representing one-hundredths of a degree. There was also no necessity for reading the barometer to three decimal places, or the temperature of the gas, and all those other figures. The figures should be given showing a degree of accuracy rather greater than the error of the instrument.

Dr. Colman said he appeared in a dual capacity; but in so far as he was not Mr. Klumpp, he could not reply to the discussion from his point of view. From his own point of view, however, he practically agreed with everything that had been said except in one point on which he had a little quarrel with Mr. Abady. The latter said that it was the net value which was most affected by variations in the moisture of the air; but he (the speaker) did not agree with this. It was the gross value which was affected by alterations in the moisture. But the amount of water condensed was equally affected; and as they got the net value by the difference between the gross value and the latent heat of the condensed water, this error was eliminated, and so far as errors due to moisture were concerned, a correct net figure was obtained. Nevertheless, he was in full agreement with both Mr. Klumpp and all the speakers that it would be very unfortunate if, for the purpose of defining a gas, they used the net calorific power, and not the gross—that was to say, for all statutory purposes the gross figure ought to be the one adopted. He regretted that in the one statutory restriction already introduced into this country, the net value had been adopted. He did not, however, think it was of much importance, because it was agreed that this was a purely tentative step, which would come up for consideration, and perhaps modification, in a couple of years. But they must be ready, when the time came, if there was going to be any increase in the statutory restrictions as to calorific power, to try and have the gross value adopted. The reasons why this was the proper course were that the gross value really represented the total potential energy of the gas and water, on the whole. The errors of determination of the gross value were less than of the net value. There was considerable difficulty in always ensuring that the water condensed during any test had come from any particular quantity of gas which was burned in that test. Owing to the large surface, there was a tendency sometimes for the water to hang up, and at other times to run down rather more quickly; so that there was always considerable variation possible in this respect. But there was another reason which he might just mention, because he thought it would become of a certain amount of importance. What was the net heating value of the gas? There were two different net heating values being used; and it might be a nice legal point, possibly, if a company were fined for being slightly below the statutory quality, as to what the meaning of net value was. He might perhaps explain this by the use of a table he had put up for another purpose which he should have mentioned first. The question of calculating the calorific power of gas from analysis, as Mr. Holgate had said, was not a thing one wanted to do as a regular practice, because it was much better and more accurate to make direct observations with a calorimeter. But it was very useful, where one had the composition of the gas, to be able to calculate the calorific power from the analysis, and it also formed a useful check on the other work. Unfortunately, the tables that were given of the calorific power of a cubic foot of various gases differed very materially—to the extent of some 7½ per cent.—the reason being that they were not given in the same terms. Some of the tables were given in the terms of B.Th.U. to the cubic foot at 32° Fahr., 30 in. barometer; others, at 60° Fahr. and 30 in. barometer, measured dry. In all actual observations, they gave the calorific result in terms of B.Th.U. per cubic foot at 60° Fahr. and 30 in. barometer, saturated with moisture; and, of course, in calculating, this was the figure one ought to use for obtaining the calorific power. It might be useful if he wrote up the calorific powers of various gases, gross and net, calculated on the basis of 1 cubic foot of gas at 60° Fahr., 30 in. baro-

Calorific Power of 1 Cubic Foot of Gases at 60° Fahr., and 30 In. Bar., Moist.

	Gross.	Net A.	Net B.
H	321	268	275
CO	321	321	321
CH_4	1003	897	911
C_2H_4	1578	1472	1486
C_6H_6	2319	2160	2182
C_6H_6 vapour	3708	3549	3570

meter, moist. They were calculated mostly from original observations by Thompsen, with the exception of the benzene vapour, in which Thompsen differed from everybody else, and he had taken there a mean figure. He put the gross figures and "Net A"—that was, the net as ordinarily ascertained. In obtaining the "Net A," one deducted from the gross value the latent heat of the steam condensed, *plus* the heat given off by the condensed water in cooling from 100°C. to the ordinary temperature. The question was, Is there any justification for deducting the latter amount of heat when ascertaining the net value? It had been the practice to do it; but it was not done in every case, and he did not think, himself, there was any justification for it. What was the use of net value? What they wanted to know was the amount of heat given off when the gas was burned. As long as the steam remained steam, the latent heat did not come out; and this latent heat was therefore heat which was only heat potentially, which did not take any part in raising the temperature of the flame, nor, in a gas-engine, did it take any part in increasing the pressure of the mixed gases enclosed in the cylinder. But this other portion that they deducted for the net included not only the latent heat, but also the sensible heat of water cooling from 100° to 15°C.; and this was really present as heat in the flame, or was present equally as heat in the cylinder of a gas-engine. Now, the only real justification for the net value was its employment in thermo-dynamic calculations, such as the maximum possible temperature of a flame, or the percentage of energy obtained in, or how near to perfection one got with, a gas-engine. For such thermo-dynamic purposes, there was no justification for deducting the quantity of heat going up by the cooling of the condensed water to atmospheric temperature. One might equally well demand that in the net determination the sensible heat carried away with the waste gases and excess of air, when these were not cooled sufficiently to condense the steam should also be deducted, as the loss of heat in this respect might nearly equal and often exceed the loss due to latent heat. It was not a point of great importance in everyday practice, as the difference between the two "net" figures is only about 1 per cent. with coal gas; but it would certainly come up in connection with the statutory restrictions, if ever the net value was fixed. This was why he raised it. Under the term "Net B" in the table, he had put what the "net" value was if one only deducted the latent heat; the difference between the two net values varying with different gases from 0·6 to 2·5 per cent., and the "Net B" figure represented the true "thermo-dynamic" net value of the gas. The popular supposition that the net value represented the quantity of heat obtainable in practice was untenable. It was simply a value which was of use from thermo-dynamic considerations; and it was of certain special value got out for thermo-dynamic purposes. In ordinary practice, as seen in the Gas-Heating Research Committee's work, the flue gases carried away from 20 to 30 per cent. of heat which could not be utilized, and under ordinary circumstances, one must have this gas going up the flue hot in order to maintain the draught. The only other point he need refer to was with regard to the units. He felt that it did not much matter in making actual calorimeter tests whether they used the Centigrade thermometer or the Fahrenheit, the pound or the kilogramme. It was so easy to convert the one into the other, and the trouble of the calculation was so small, that it did not matter in actual practice whether one adopted the American principle or not. But what he did feel was that the practice which had also arisen in connection with the existing statutory testing, of expressing the results in calories per cubic foot, ought to be distinctly deprecated. If one was going to speak of cubic feet, he ought to speak of British thermal units throughout—not take a hybrid thing like calories per cubic foot. He must, at the same time, point out that the people who started this procedure were individuals who deserved a large amount of blame in this respect. Ten years ago, there was a paper read on "Calorific Power" before the old Institution of Gas Engineers, under the same President as they were sitting under at present; and the writer of the paper gave all his results in calories per cubic foot. He himself was that guilty person, and he could only say that he stood before them at that moment in sackcloth and ashes; and he must express regret for the error, which was due to thoughtlessness, probably, at the time. He would promise to try not to do it again.

MANAGEMENT OF SMALL GAS UNDERTAKINGS AND WORKS.

By FREDK. J. WARD, of Knowle.

The gas supply to small districts and the management of the undertaking and works frequently present difficulties; and in attempting to examine them the author is only justified by the circumstance that he has spent the greater part of his association with the gas industry in small works. It is not his intention to enter closely into details—a few only will be dealt with (although he may at once say that the success, or otherwise, of undertakings depends to a very large extent upon the manner in which details are considered)—but to view the subject generally, giving a few figures, and particulars of the methods adopted to obtain them, relating to the works and undertaking with which he is now connected.

A glance through any gas directory will show that a very large percentage of the works existing in the United Kingdom are producing less than 20 millions per annum; and it is to such works that the present paper will chiefly apply.

With regard to the position of small undertakings, no exception can be taken to the statement that there are numerous instances where amalgamation of undertakings near each other, linking-up the districts by connecting mains and concentrating the manufacture upon the works most advantageously situated for delivery of coal, sale of residuals, manufacture of sulphate of ammonia, and the general convenience of consumers, would result in such large economies being effected as to ensure to the proprietors an increased dividend on their holdings, and to the consumers a lower price for gas—the latter being a great desideratum. When closely examined, it is somewhat surprising to find the extent to which it would be a financial success to lay connecting mains and link-up districts, and regret must be expressed that more amalgamations are not effected. The author is acquainted with several gas undertakings where amalgamation with others would be beneficial, and are almost absolute necessities. The jealousies of boards of directors, and sometimes of the officials, however, tend to prevent such a course; but possibly in time they may be overcome. The chief difficulty appears to be that close attention cannot be given to the requirements of consumers, owing to the works being situated away from the bulk of them. But it can be surmounted by arranging to have a card or telephone call with response by cycle or car.

With reference to the amalgamation of several undertakings too far apart to be linked-up by mains but which could be all merged into one company and controlled by station or resident managers under the supreme control of a general engineer, manager, and secretary, some such combinations have already been inaugurated, but a large number more might be arranged. This scheme offers great possibilities; in fact, the opportunities for good work appear to be limitless. The combination of, say, six to twelve works all situated within such a geographical area as would permit of most of them being visited during a single day by the chief officer, travelling by motor car, would offer such facilities for supervision as would be sure to produce satisfactory results. The headquarters of the company should, if possible, be situated in the most convenient (for railway and administrative purposes) town or district, and the chief officer should be an experienced engineer, an able accountant, and should also act as secretary. He should be a man thoroughly familiar and versed in all the problems and intricacies of small works, and be able by practical example, if necessary, to keep the resident managers alive to their duties, responsibilities, and interests. The resident managers themselves should be selected men of conscientious principles, thoroughly practical in all the work of gas manufacture, able to carry out all the usual duties connected with distribution, and capable of keeping works' books and rental ledgers, and collecting accounts.

By the system of combining several small undertakings, numerous economies could be effected, such as in the purchase of coal, stores, and materials. The purchase of new plant could be so arranged that the displaced plant, such as purifiers, condensers, washers, and scrubbers, could be re-

moved and fixed at smaller works. Special workmen, such as retort-setters, fitters, &c., could be employed, and sent from works to works as required. In many instances, it is often a serious question as to how any extensions of works or distributing plant can be undertaken; and if the manager has to carry it out in addition to his ordinary duties, the progress of the undertaking ofttimes receives a check, through the work being inefficiently performed owing to being done in a hurry. Special tools and appliances could be kept and used at the various works as required. The point of emulation in results would be one which would be fruitful, as the resident managers would vie with each other in being on the top rung of the ladder of results, each one knowing that his work and results would be always under comparison with others of the same combination. It would be a disadvantage if the number of works or the area covered were too large and unwieldy, as the success of the scheme would rest largely in the constant supervision. The question of salary of the chief officer could be satisfactorily arranged; for even if only six works were combined, the savings produced would far outweigh the amount of the officer's salary and that of an efficient clerk. The salaries of the resident managers should be ample, and, if possible, partly fixed by results.

Passing on to consider self-contained undertakings—*i.e.*, those which through reasons which need not be mentioned here will always be independent of any other undertaking—the views held by the author are somewhat unusual. He is of opinion that the posts of manager of the works and secretary to the undertaking should be combined in the one person—holding this opinion partly because he is firmly convinced that no person should be appointed as manager unless he is an able accountant and well versed in company law and procedure. Some part of management is the study and preparation of statistics, such being of valuable use for comparative purposes. The combination of the two offices does away with the red-tapeism which unfortunately frequently exists when the offices are uncombined, and the close association of the only official with the board of directors is usually productive of harmony. The consumers, too, are always the gainers by the combination, for any communications or requirements can be promptly attended to without the irritating (and frequently unremunerative as far as the undertaking is concerned) reference to the other department. The manager and secretary should also be able to perform all the duties of engineer in the designing and preparation of drawings, &c., relating to extensions or re-construction of works and plant. On this point the author does not wish to be misunderstood. He is fully aware that many able engineers are acting for small undertakings, often with beneficial results; but he seriously holds the opinion that the resident manager should possess all the requisite knowledge and ability for capably carrying out such duties. The presence of an expert on the board of directors is often a great assistance to the manager, such expert being able to strengthen his hands when presenting any new scheme or suggestion before the board, and no one ought to object to him having a seat on the board.

The success of a small undertaking depends in a large measure upon the ability and willingness of the official to perform any hard practical duties. He should be expert in the use of all tools and appliances, and he should love work as a civil engineer loves steel and puddle. But he is not required to ever be in a condition that he cannot meet with any consumer, director, &c., who interviews him at the works; and above all he should always be a gentleman in the best sense of the word.

Dealing briefly with a few points which go to ensure success, the charging of retorts should be accomplished rapidly, the charge laid evenly, and the lid closed quickly. The ascension pipes should be augered with a large auger (this is very important, and is too often sadly neglected), so that scarcely any more pressure exists in the retorts at the commencement of the destructive distillation of a charge than at the finish. The retort-house should be kept clean and tidy. The producer grates should be pricked-up every 2½ to 3 hours, so that the false bars for cleaning purposes should seldom need to be inserted. If properly attended to, cleaning should not be required more frequently than every six months. Mains should never be laid with a less covering than 2 ft.; and if possible they should be covered 2 ft. 6 in. In connecting services with mains, the use of two bends instead of one reduces the strain, and consequently leakage very considerably, and services should be kept covered to as great an extent as possible. The use of any coating on mains, especially internally, is to be condemned, as the solvent action of the gas quickly causes the joints to leak. The thickness of the charge in the retort is at present the subject of controversy. The author, through being handicapped by having to rely upon hand work, has not been able to experiment much in this direction. He finds that a retort two-thirds full is best suited for his requirements. Small works appear to be severely left alone in the use of retort-house machinery, as no machine has yet been designed to take the place of the stoker and yet be sufficiently low in price to be within the means of small undertakings. The salaries paid to officials is a much debated question, but the author's experience is at variance with the generally expressed opinion that salaries are inadequate.

Dealing now with actual experience the author proposes to point out the results which have followed the application of the foregoing principles to the undertaking at Knowle with which he has been connected for over twelve years.

The Knowle Gas Company was established twenty years ago, when the author was appointed to the triple post of Engineer, Manager, and Secretary, and the result of his first year's work was a make of 2,695,000 cubic feet and a sale and accounted-for of 2,523,650 cubic feet—a difference of 171,350 cubic feet or 6·35 per cent. unaccounted for. From this point onwards, matters have progressed steadily; and for the twelvemonth ended March 31, 1910, the gas made was 9,763,600 cubic feet, and the gas accounted for 9,404,800 cubic feet, the difference being 358,800 cubic feet, or 3·67 per cent. as unaccounted for. This shows an increase in gas sold and accounted for equal to 272·6 per cent. in eleven years—a fairly satisfactory rate of progress. The coal used was $793\frac{6}{20}$ tons, this giving a make of 12,307 cubic feet per ton, 11,855 cubic feet per ton being satisfactorily accounted for. During the period of eleven years, the mains have been extended about $33\frac{1}{3}$ per cent.; and the increase in the number of inhabitants in the district supplied is about 20 per cent., thus showing that the bulk of the increase has been on the old system of mains. The price of gas has been reduced from 5s. to 3s. 6d. and 3s. 4d. per 1000 cubic feet. The present length of mains is $6\frac{3}{4}$ miles; and as the unaccounted-for gas is 358,800 cubic feet, this shows the extremely low figures of 53,289 feet per mile of main.

The last financial statement was for the year ended June 30, 1909; and as no further figures are yet available, those for that period are shown, though those for the year shortly to be ended are much better for several reasons—such as cheaper coal, greater sales, increased production per ton of coals carbonized, &c. The amount of capital raised when the author commenced his duties was £4500, being equal to £1707 per million cubic feet of gas sold and accounted for. At present, the amount of capital raised (including premiums) is £8000, this being equal to £819 per million cubic feet sold and accounted for. For the last year of the old *régime* and the first year of the author's management, no dividend was available for shareholders; but since then matters have so improved that 10 per cent. (free of tax) on the share capital, which is 62½ per cent. of the whole, has been declared for the past six years, and the usual interest on debentures.

The summary of the last accounts is as follows:—

Manufacture—			
Coal (*less* residuals), purification, salaries and wages, and repairs and maintenance of works .	£520	18	5
Distribution and management—			
Rents and rates, repairs and maintenance of distribution plant, salaries and wages, Directors and Auditors, and establishment charges . .	229	4	4
Gross cost of gas	£750	2	9
Less meter rents, stove rents, fittings rents, profit on fittings, and miscellaneous receipts. .	108	10	10
Net cost of gas	641	11	11
Gross profit	986	0	11
	£1,627	12	10
By revenue from gas	£1,627	12	10

The gross profit was disposed of as follows:

Manager's percentage of divisible profits and the amount that is added to the depreciation and renewal fund	£158	8	11
Income-tax	33	6	0
Added to reserve fund	100	0	0
Balance written off fittings installations . . .	54	13	9
Debenture interest.	96	0	0
Dividend at 10 per cent. on share capital . . .	540	0	0
Balance carried forward	3	12	3
	£986	0	11

Attention is called to the fact that—so far as the manager is concerned—profit-sharing is in vogue. The author here simply mentions the fact and does not desire to comment further; he having mixed feelings on the subject.

The accounts show that the cost of gas into the holders was 13·29d. per 1000 cubic feet sold, and that the net cost of gas was 16·37d. per 1000 cubic feet sold. It may be argued that the amount of manager's percentage of profits and the addition to the depreciation fund ought to be added to the net cost, but the author does not favour that view.

Referring to the plant at Knowle, it may at once be said that there is nothing novel in it. The works are of the usual formation, and may be termed in some respects behind the times. In the retort-house the work is all done by hand, the mouthpieces are sealed with luted lids, and no modern inventions—such as anti-dips, tar columns, retort-house governors, &c.—have as yet been adopted, and the dip-pipes are sealed in the condensed liquids as formed. Notwithstanding that the yields per ton may be regarded as good, it is not considered that finality is yet reached, although there is a limit to the capabilities of workmen. The average production per mouthpiece from retorts 21 in. by 15 in. by 8 ft. 3 in. inside, is 8200 cubic feet per diem. The coal used is two-thirds South Yorkshire and one-third North Staffordshire.

The foul main and condensers are large, as they always should be, thus ensuring a very free passage for the gas, with practically no friction. The exhauster, which is two-bladed, is driven rather fast to prevent the impulses being marked in the hydraulic main; and the motive power is derived from a gas-engine. The cost of driving exhausters by gas-engines with gas at holder cost, is about one-third that of driving by steam, when steam is raised, as is usually the case in small gas-works, in a vertical unlagged boiler. It is true that steam is occasionally useful for warming purposes; but it can very easily be provided for by having a small vertical portable boiler, such as is in use at Knowle. The use of luted lids may appear to be antiquated; but no other kind will be adopted by the author, for he is convinced that by their use there is less loss of gas, the quality is better, and the retort-house is kept cleaner. They also tend to prevent the charge which is often made, that more is taken out of the retort than is put in it.

It is an interesting fact that, notwithstanding the small amount of unaccounted-for gas, the pressure of gas is always maintained at the full, which is 25-10ths. The author is of opinion that, instead of increasing the leakage, it has the opposite effect; leaks which would otherwise be undetected at lower pressures are detected and stopped when laying mains and services. Moreover, much greater satisfaction can be given to consumers—complaints, owing to lack of pressure, being unknown. The practice of this principle has been prevalent for at least eleven years.

In conclusion, the author holds that there is no royal road to the successful management of small undertakings, but that the "man-in-charge" must be born with a natural aptitude for steady, plodding, and unwearying work and for overcoming difficulties; that he must be continually on the *qui vive* to make the most and the best of everything; that cleanliness, order, and system are absolutely essential; that a good knowledge of chemistry and physics is desirable, but that it must be combined with sound common sense and ability; and that the manager in carrying out his multifarious duties must ever keep in mind all that is conveyed by the term "gentleman" in its fullest sense.

Discussion.

Mr. T. J. Reid (Ballina) said that—coming as he did from the Sister Country, where small gas-works were greatly in the majority, and where they, more or less, pursued an active existence—he had looked forward with great pleasure, and with something akin to the sensation of a hungry man anticipating a feast of good things, when he heard that such a paper was to be brought forward. However, he must confess that his feelings now could be compared with those of the aforesaid hungry man, who, instead of enjoying a good, square meal, had been regaled with *hors d'œuvres*. He had hoped to return to his own country laden with information which might be applied to the more successful management of the concern over whose destinies he presided; but he was afraid he must content himself with continuing to use the methods he had considered to be peculiarly his own. It was not his desire to depreciate the writer's efforts in bringing forward this paper. Valour was an estimable quality, and some degree of courage must have been necessary for the writer, to come and read such a paper before an Institution of this sort. He congratulated him on his success in this respect, and congratulated the Council on their action in accepting such a paper, as evidencing their friendly attitude as a body, and individually, to managers of small gas-works. The title of the paper was "The Management of Small Gas Undertakings and Works;" but he did not think the writer had treated the subject in a manner to justify such a title. Apart from a recapitulation of the highly satisfactory results attained by him in the management of his own works—a fact on which Mr. Ward as well as his Directors were to be heartily congratulated—very little had been said as to the management of small works generally, or as to any particular factor in the management of the Knowle Gas-Works which had led to such magnificent results. It was remarkable that he did not touch upon the one phase of management on which the manager of a small gas-works might be expected to know something more than his brother in larger works. He referred to that which was the principal theme in the President's Address, and which had from time to time been discussed there and elsewhere—namely, the means which must be adopted to further the sales of gas and to ensure to the consumer the full benefit in light, heat, and power of the gas he bought. He was informed that the voice of the Irishman was not unknown in Westminster, and that his vote, or voice, was considered of some little value. Thus encouraged, he would tell his fellow-members what had been done in this respect in some of the small gas-works in Ireland. It must be remembered that there a small gas-works producing under 10 million cubic feet per annum had to cater for an entirely different *clientèle* from that of a similar sized works in England—one that would be probably supplying a village, or perhaps a colliery or manufacturing district, where the consumers were more or less of one class. In Ireland, the small towns, although of a population not exceeding some of the English villages, possessed all the elements of a city, with all the varying grades of society from peer to peasant; and therefore their gas requirements were very varied, and necessitated a knowledge on the part of the manager of every branch of gas distribution and consumption. When the incandescent burner came into use, it was soon evident that, if they were to maintain the position which their good qualities entitled them to, special means must be adopted to prevent the position being prejudiced by weaknesses inherent in the incandescent system. It was considered that they were dealing with an illuminant as different from ordinary gas lighting as electricity itself; and a new illuminant necessitated peculiar treatment. Thus, coincident with the growth of the incandescent light, there had grown up in the towns a system of supervision of every incandescent burner in use which had been extended to other apparatus. This was absolutely free; the cost price for materials only being charged—and even, in some cases, these were not charged for. The condition of affairs was now such that consumers demanded that their burners and fittings should be kept in order free of charge, and full responsibility was presumed by them, and assumed by the gas company. This condition had not been forced on them, but had been fostered and encouraged as being absolutely essential to the conduct of their business. It was strange, then, to hear it gravely propounded on this side of the Channel that something of the sort was necessary. It seemed to him that the importance of the matter had not been fully grasped; that they allowed themselves to be forced into a position which they had better have occupied of their own accord in time. He was not a prophet, or the son of a prophet; but he thought it would better pay some of the larger works to foster and retain such lighting consumption as they had, by supplying incandescent burners and mantles and maintaining them free, than by embarking on schemes of free slot-installation. Even the President, in his address (which he was not going to criticize), conversant as he seemed to be with the importance of the whole matter, disclosed something of the attitude of the gas profession, when he said it was useless to disguise the fact that the profession were becoming shopkeepers, or something to that effect. Why disguise the fact? They should advertise the fact that they were "out for business," and were actually purveyors of light, power, and heat. It would be far better, in his opinion, that consumers should be asked to pay a penny, or even sixpence, per 1000 cubic feet more, if by so doing they obtained a better service. He had simply

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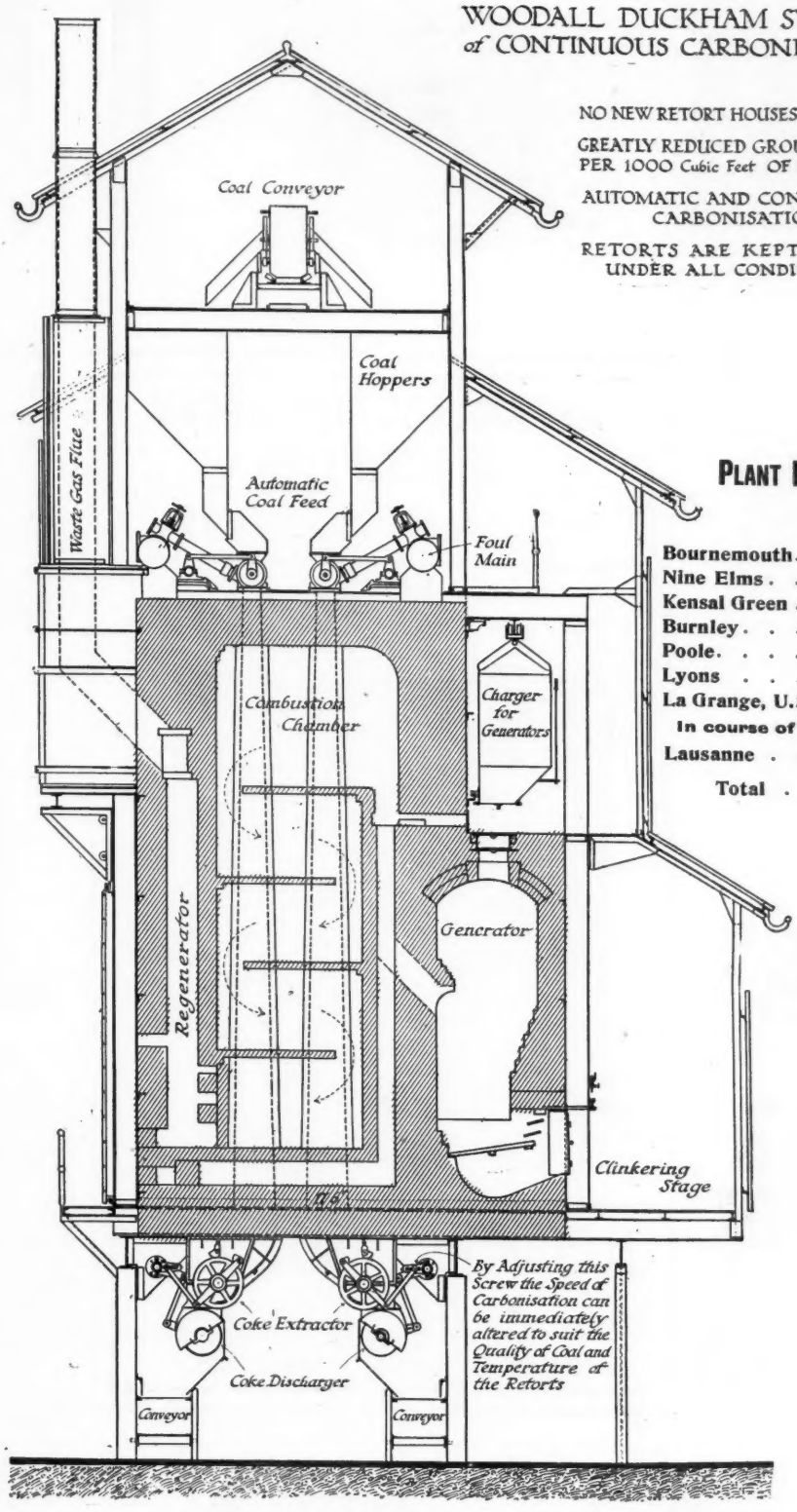

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described a condition of affairs that had existed in Ireland for many years, but which did not appear to have obtained the same position here. With regard to the paper itself, he had not very much to say. Dealing with the question of amalgamation, something might be said for this, for manufacturing and distributing purposes, for gas-works closely situated; but this condition did not apply in Ireland, where the gas undertakings were separated by many miles. So he would leave it to be discussed by managers who were brought more closely in contact with the actualities of the case. The question of the combination of small gas-works had been discussed frequently in Ireland, where a number were in combination; but perhaps the discussion of this point had better be left to those present who had better information. He believed, however, that such works in combination had been a distinct success, though he could point to others not in combination which were certainly quite as successful. He noted that the writer insisted that the resident managers of the works in a combination should possess qualities, moral and otherwise, of a very high character. He trusted that these qualities were not exceptional in managers of small works in England. At any rate, he could vouch for their possession by the managers of small works in Ireland. The paper showed such remarkable faculty on the part of the writer in giving information which furnished no opportunity of definite criticism, that it reminded one of the conjurer who, having performed a good trick, proceeded to show how it was done, and left the audience more mystified at the end than they were at the beginning. There was really nothing to criticize in such details of the working as the paper had disclosed. But the author was particularly happy in being able to do without cleaning his producer for six months at a time. Getting more than 12,000 cubic feet of gas per ton, and 8200 cubic feet per mouthpiece from retorts of small dimensions, was distinctly good. He trusted Mr. Ward might be able, in his reply, to give some hints as to how this was accomplished; and that he would say what was the life of his retorts and the calorific value and illuminating power of the gas. In conclusion, he again congratulated the author on the excellent results he had obtained. Doubtless the example he had given them would encourage a spirit of emulation which would be productive of good results.

Mr. Thomas Berridge (Leamington) said he should like to congratulate Mr. Ward on the excellent results he had obtained. If he himself could do the same, it would mean a saving of £3000 a year on coal, and to a near neighbour, it would mean from £30,000 to £40,000 on the coal bill, so that he might congratulate him very heartily. That the quality of Mr. Ward's gas was all right, he could personally testify, because he had tested it. He agreed largely with what the author had said right through; but he did not think it was a good thing to have these amalgamations, if some financier was to step in and take a lot of profit out of it. There was one way in which it could be done, however. Many managers were also chairmen, directors, and consulting engineers of small works. He had some dozen under his own care; and he invariably made contracts for all of them, getting the same results, and the same prices as if the companies were amalgamated. If Mr. Ward would adopt modern improvements, he thought he would soon startle them with the results he obtained at Knowle—if he would have his mains without seals, fix a retort-house governor, admit 1 to 2 per cent. of air in his gas to save purification, and use a Leigh's automatic pressure arrangement. He quite agreed with the last speaker that Mr. Ward did not push his sales quite so much as he might do. He had no show-room. If he had a show-room, and gave more information about slot-installation and free fittings, he thought he would soon double his consumption.

Mr. C. S. Ellery (Bath) said he should like to ask a question, so as to elicit if possible some information which would be very valuable. It had frequently been a puzzle to him, with regard to small works, as to what was the most economical setting of retorts. With regard to the remarkable results they had heard of at Knowle, he should like to know how many retorts Mr. Ward was using to each furnace. He had given the size of the retorts, but had not told them how many he had in each setting, and whether he had regenerative furnaces. He saw one line in the method in which he disposed of his gross profits, which perhaps might be part of the secret of his success. The one he referred to was "balance written off fittings installations." He thought he saw from this, and from the further statement as to the capital per million cubic feet of gas, that Mr. Ward seemed to be fully alive to the necessity of letting the revenue account bear its proper burden each year. Small works frequently made the mistake of putting as much to capital as possible. What they saw here seemed to him to show that the author had learnt that the secret of success was to make revenue bear as much of the burden as possible. He congratulated Mr. Ward highly, not only on his interesting paper, but also on the admirable results it indicated.

Mr. R. W. Edwards (Aldershot) also congratulated the writer on the results he had obtained, but thought they did not bear out his suggestion that amalgamation was a desirable thing. If small gas-works could obtain such excellent results as he did, there was no need to amalgamate. Following out the question asked by Mr. Ellery, he would like to know the quality of the gas and the burner by which the gas was tested.

Mr. S. O. Stephenson (Tipton) said if any great advantage was to be gained by the amalgamation of small neighbouring works, it was more in the concentration of manufacture at one centre rather than in retaining all the small works going. Mr. Ward was to be congratulated on his results; and he agreed with what Mr. Berridge said, that rather than require the manager of one of these small works to have exceptional engineering knowledge, which he did not think was necessary, he would be better occupied in attending to the business side of the undertaking. This was much more important than for a small manager to be able to undertake extensions.

Mr. Ward, in reply, said he was not used to public speaking. If he had such a flow of eloquence as the gentleman from Ireland, he should be perfectly happy; but, unfortunately, he had not. When his paper was first written, it was rather longer than it was now. The Council thought fit to send it back to him to curtail; and he had had to cut out a lot of the matter which the gentleman from Ireland had expressed a desire to see. Consequently, they had a very much abbreviated paper, which was practically a record of what had happened at Knowle. Mr. Reid had asked why he did not take up the subject of the sales of gas. This was the reason—that a good deal of his paper had been cut out. He did look after the gas distribution. He did the whole of the fitting work himself; and, as a matter of fact, they made a profit of £30 last year on distribution. The Company did 95 per cent. of the fitting work at Knowle. Of course, they were close to Birmingham, and the people were largely Birmingham people. This was one reason why they had no show-room. If they had one, the people would not buy from them. What they preferred to do was to go to Birmingham and select the fittings, and then bring them over, and have them fitted up by the Company. In regard to the Irish gas managers, they were somewhat differently fixed there from what he suggested should take place in England. He referred to gas-works not sufficiently close together to be linked up by mains, but sufficiently close to be dealt with by one engineer. With regard to the calorific value of the gas, he might say that the net result averaged about 530 B.Th.U. As to the illuminating power, he took very little notice of this, because they were a non-statutory Company. So far they had not provided themselves with a proper bar apparatus or a table photometer. He worked entirely by the jet; and he was surely not foolish enough to alienate his customers by giving them what they did not want. He gave them something they were contented with, and on these lines he was satisfied to continue. He could tell readily if the calorific value was good or not, because he had a gas-engine which worked directly off the distributing main as it left the holder; and this quickly informed him if the calorific value was not right. As a rule, it seldom varied, because they took very great precautions to watch the pull. When he put in a charge in the retorts, he did not work in the ordinary fashion. It was customary to split the charge up, and keep a man charging all the while. But they did not do this. They put in a full charge, and put the pull on rather heavily at the commencement; and it was gradually decreased during the whole charge. By this means, they maintained the same pull all the way through. He had to work all the gas into a heavy holder, and distribute it out of another for mixing purposes. Mr. Berridge thought he would do better if he put in a retort-house governor. He had quite an open mind about this; but so far he had not seen the necessity, because the gauge on the hydraulic was practically level—there was no oscillation at all. By working the gas-engine fast, they

were able to get a very steady gauge indeed. His retorts were five in a bed. This was a good thing for feeding the producers; but beyond that he did not like it. He should much prefer to have four in a bed, and have them somewhat higher. The bottom retorts did not get so hot as the top ones; and, whenever he had an opportunity, he put the bottom retorts out of action, and only used the top ones. With regard to the gross profits, they went in for fitting installations in small houses. They had altogether about 150; and they had wiped off the total cost of these installations in about three or four years.

REPORT OF CARBONIZATION COMMITTEE.

The Sub-Committee having in hand the investigation of the various methods of carbonization—Messrs. Charles Carpenter (Chairman), Edward Allen, J. Ferguson Bell, A. E. Broadberry, Thomas Glover, W. Langford, John W. Morrison, Alexander Wilson, and S. Y. Shoubridge (Hon. Secretary)—report that they have been disappointed in their endeavours to arrange for a comparative test, made as far as possible under identical conditions, of the three best known systems of vertical retorts, difficulties having arisen which necessitated the abandonment of the project. One of the members of the Committee has, however, furnished the details of an investigation into the working of horizontal retorts with full charges; and this communication will, it is thought, form a valuable supplement to the paper he contributed last year to the Institution's "Proceedings." The particulars of this investigation will be presented at the forthcoming meeting of the Institution.

Investigations with Respect to Carbonizing in Horizontal Retorts.

By J. Ferguson Bell, M.Inst.C.E., of Derby.

The importance of working horizontal retorts to obtain the best results, both in respect to the gaseous, liquid, and solid products obtainable from the coal carbonized, and so as to achieve comparative results, led the author to carry out a week's trial under ordinary working conditions with Derbyshire gas coal of average quality—the fine slack only being removed. Arrangements had previously been made with the colliery for exactly similar coal (Derbyshire Blackshale, an analysis of same being given in Table I.) to be supplied during these trials at the Litchurch Gas-Works, Derby. In No. 1 retort-house, the period of carbonization was twelve hours' duration, and in No. 2 retort-house eight hours.

TABLE I.—*Composition of Derbyshire Black Shale Coal Used During Week's Trial.*

Sp. gr., 1·374.

	Per Cent. Wt.
Carbon	72·22
Hydrogen	4·75
Nitrogen	1·35
Sulphur (volatile)	2·31
Ash	7·51
Moisture	4·49
Oxygen by difference	7·36
	Per Cent.
Total sulphur in coal	2·43
Volatile matter	33·98

Analysis of Coke Produced.

		Sp. Gr.	Carbon.	Volatile Matter.	Total Sulphur.	Ash.	Moisture.
No. 1 retort house	12 hr. charges	1·59	84·82	1·838	2·78	10·34	0·664
No. 2 retort house	8 ,, ,,	1·63	84·05	1·021	2·415	10·11	0·629

In both houses the tests were carried on simultaneously (March 17 to 24, 1910), and the conditions as far as possible were similar in respect to the method of charging and the heat of the retorts; the only difference being the weight of charge and the period of carbonization.

The gas made (corrected to 30 inches bar., 60° Fahr.), illuminating power ascertained by the No. 2 Metropolitan test-burner, impurities, and calorific value were taken every two hours during the trials; and, in addition, average samples of purified gas were taken for analysis at the rate of ½ cubic foot per hour into a 10 cubic feet capacity test holder—a sample of the mixed gas being drawn therefrom into gas sample tubes to ascertain its composition. The temperatures of the retorts just before charging and in the combustion chambers of the settings were taken periodically by a Féry spiral pyrometer.

In No. 1 retort-house the settings are eights, three tiers, D section, 22 inches by 16 inches by 18 feet through, heated by Klönne regenerator furnaces with light hydraulic seals on the dip-pipes; and in No. 2 house the retorts are of similar size and section, set in four tiers, Klönne regenerators, with anti-dip pipes. Carpenter's retort-house governors control the suction on the hydraulic mains in both the houses. Care was taken to ensure zero pressure as near as possible on the inside of the retorts during the trial.

The gases from Nos. 1 and 2 retort-houses were kept separate, and purified by oxide only—being previously passed through Livesey tower and rotary washers.

TABLE II.—*Summary of Results Obtained from a Seven Days' Trial (March 17 to 24, 1910), of Derbyshire (Blackshale Seam) Gas Coal, Fine Slack only Removed, Carbonized by Charges of Eight and Twelve Hours' Duration.*

—	No. 1 House 12 Hour Charges.	No. 2 House 8 Hour Charges.
	Cub. Ft.	Cub. Ft.
Total quantity of gas made (corrected 30 inch bar. and 60 Fahr.	3,585,100	8,881,900
Total quantity of coal used	296 tons 10 cwt.	751 tons 8 cwt.
Average weight of coal per charge	12 cwt.	8·21 cwt.
,, duration of charge	12 hours	8 hours
Gas made per ton of coal (30 inch bar. and 60 Fahr.)	12,091 cub. ft.	11,820 cub. ft.
Illuminating power (No. 2 Metropolitan burner)	15·56 c.p.	16·29 c.p.
Sperm value per ton of coal	645 lbs.	660 lbs.
Calorific value of gas per cub. ft. gross.	608·2 B.Th.U.	586·8 B.Th.U
Do. nett	554·6 ,,	530·4 ,,
CO_2 in crude gas per 100 cub. ft.	2·5 per cent.	2 4 per cent.
SH_2 Do.	1040 grains	933 grains
CS_2 Do.	65·9 ,,	57·3 ,,
Total coke sold—large screened	139 tons 7 cwt.	334 tons 11 cwt.
Do. small ,,	36 tons 13 cwt.	111 tons 4 cwt.
Do. breeze	11 tons 13 cwt.	27 tons 16 cwt.
* Coke made for sale per ton of coal, large screened	9·40 cwt.	8·90 cwt.
* Coke made for sale per ton of coal, small screened	2·47 cwt.	2·96 cwt.
* Coke made for sale per ton of coal, breeze	0·78 cwt.	0·74 cwt.
Coke used on furnaces per ton of coal	1·60 cwt.	1·65 cwt.
Do. 100 lbs. of coal	8·00 lbs.	8·25 lbs.
Total quantity of tar made	3579 gallons	7840 gallons
Tar made per ton of coal	12·07 ,,	10·43 ,,
Average sp. gr. of tar (water 1·000)	1·156	1·189
Total quantity of ammoniacal liquor made 5° Tw.	10,536 gallons	25,459 gallons
Ammonial liquor made per ton of coal 5° Tw.	35·53 ,,	33·88 ,,
NH_3 in lbs. of sulphate of ammonia	29·89 lbs.	28 50 lbs.

* The coke and breeze contained an average of 6·56 per cent. of water, the bulk of which was in the small coke and breeze.

The comparative results given in Table II. conclusively indicate, so far as the residual products—coke, tar, and ammonia—are concerned, that there is a decided improvement in their production, which confirms the results given by the author in the paper read before the Institution in June, 1909.

The coke is somewhat harder, and the proportion of large screened is greater. The colour is improved, being silvery grey. The fracture in the filled retorts is radially from the centre outwards—something similar to that from coke-ovens. Coke analyses of eight and twelve hour charges are given in Table I.

To accurately ascertain the exact quantity of coke made, certain charges were pushed out into a rectangular iron vessel with an air-tight lid. The hot coke was cooled by spraying water on the outside of the vessel. It was found that this method of cooling the coke effected a decided improvement in its appearance, and there was less breeze made than when it was quenched in the ordinary manner.

There is a decided increase in the quantity of tar, which is thinner. Later, the author will probably supplement the figures with distillation tests of the tars produced.

The production of ammonia shows a decided increase—the production being, for twelve-hour charges, nearly 30 lbs. of sulphate per ton of coal carbonized. The nitrogen in the coal used averaged 1·355 per cent. by the Kjeldahl-Gunning method of estimation; so if the whole of the nitrogen could be converted into ammonia (NH_3) the theoretical yield of ammonium sulphate, $(NH_4)_2SO_4$, would be 143 lbs. per ton of coal carbonized. This is, of course, impossible, as 35 to 40 per cent. or more of total nitrogen in the coal remains behind in the coke, and also part of the free nitrogen in the gas comes from dissociation of the ammonia.

The sperm value is higher than the figures given in the author's paper on this subject last year. It will be noticed that they are almost the same for both the eight and twelve hour tests.

Although the sperm value is slightly lower for the longer charges, yet the calorific value is higher, indicating that the illuminating power and calorific value do not bear a strict relation to each other.

The sulphuretted hydrogen and carbon bisulphide are both somewhat higher in these tests for the heavier and longer charges, which is contrary to that experienced in other similar tests. The carbonic acid, on the other hand, is practically the same in each—being 2·4 and 2·5 per cent. by volume respectively.

TABLE III.—*Analysis of Gases—Sample Taken at the Rate of ½ Cubic Foot per Hour into a 10 Cubic Feet Test Holder.*

Composition of Gas.	No. 1 Retort-House. Twelve-Hour Charges.		No. 2 Retort-House. Eight-Hour Charges.
Carbon dioxide	2·20	..	2·60
Illuminants	3·80	..	3·30
Oxygen	0·30	..	0·30
Carbon monoxide	5·60	..	5·20
Methane	32·90	..	34·00
Hydrogen	48·60	..	43·50
Nitrogen (by difference)	6·60	..	11·10
	100·00	..	100·00
Calculated calorific value from composition of gases	B.Th.U. 567·6	..	B.Th.U. 550·2
Average of tests by Junkers calorimeter made during collection of samples	566·0	..	515·2

In Table III. is given the average composition of the gases obtained. The author was somewhat surprised to find the percentage of nitrogen so much in each, especially as the carbonic acid is quite normal. The nitrogen being obtained by difference may account to some extent for the higher figure.

It is of interest to note that the net calorific value of the gases ascertained by calculation from its composition and that obtained by Junkers calorimeter are—especially in the heavier twelve-hour charges—almost in agreement.

The mean average temperatures of the retorts in both houses taken (just before charging) by a Féry spiral pyrometer, it will be seen are almost identical; being in No. 1 house, 995° C., and in No. 2 house, 986° C., which is moderately high. See Table IV.

TABLE IV.—*Temperatures of Retorts and Combustion Chambers Obtained by Féry Spiral Pyrometer.*

Average Retort Temperatures in No. 1 Retort-House.

Twelve-Hour Charges.

Retorts.		Degrees C.		No. of Readings Taken.
A, B, C	Top row	970	..	13
		960	..	17
		988	..	14
D, E, F	Middle row	1010	..	5
		1034	..	9
		1026	..	5
G, H	Bottom row	995	..	8
		975	..	7
		8)7958		78

995 mean average.

Combustion Chamber.

Setting No. 1	1230° C.	
,, 2	1375 ,,	
,, 10	1335 ,,	
,, 11	1340 ,,	
,, 12	1320 ,,	
,, 13	1395 ,,	
	6)7995	

1332·5 mean average.

No. 2 Retort-House.

Eight-Hour Charges.

Retorts.		Degrees C.		No. of Readings Taken.
A, B	Top row	1000	..	40
		1041	..	11
C, D	Third row	981	..	26
		1004	..	32
E, F	Second row	972	..	11
		954	..	85
G, H	Bottom row	976	..	11
		961	..	43
		8)7889	..	259

986 mean average.

The following are supplementary notes by Mr. BELL.

It is by the courtesy of the Carbonizing Committee that the results of the recent investigation into the working of horizontal retorts with full charges are placed before the members; and they may perhaps be of interest as a supplement to the paper the author had the privilege of contributing to the Institution last year.

Before the advent of incandescent burners, flame luminosity was of much greater importance than it is to-day; hence the production of gas of high illuminating power was then of primary consideration. To this end, thin charges quickly burnt off were found to give the results desired. However, the conditions regarding the supply of town's gas have during the last few years undergone a considerable change. Flame luminosity is of much less importance; and the problem now is to supply the greatest number of heat units, at the lowest possible cost, in such a form as is most suitable for the requirements of consumers who use in increasing quantities gaseous fuel for light, heat, and power. No doubt one of the essential conditions of efficient carbonization is the production of as large a quantity of gas as possible—due consideration being given to other factors—of a reasonable candle power, nowadays generally found suitable and satisfactory to consumers when it is from 14 to 17 candles, tested by the "Metropolitan" No. 2 burner, and of a calorific value of (say) 500 to 550 B.Th.U. net per cubic foot. This does not mean an attenuated, weak, or diluent mixture containing a high percentage of useless and harmful non-combustible gases.

The investigations carried out by the author strengthen and confirm the belief that, under the changed conditions briefly referred to, many advantages are obtainable by carbonizing in filled retorts with a longer period of distillation. There is a decided increase in the quantity of gas evolved, though the flame luminosity is somewhat lower. But there is a much less proportionate reduction in the calorific value of the gas than in the candle power.

Referring to Table II., which is a summary of the results obtained from a seven days' continuous trial under ordinary working conditions with Derbyshire gas coal (Blackshale seam), there will be seen the make of gas and its illuminating power taken every half hour, and comprising 336 observations and tests. The calorific value and impurities are the average of 84 tests, taken alternately each hour on No. 1 and No. 2 retort-house gas at the Litchurch works. It is of interest to observe that similar coal, with heavier charges and a lengthened period of distillation, gave 12,091 cubic feet of gas of 15·5-candle power, with a calorific value of 554 B.Th.U., whereas with lighter charges and shortened period of distillation, the gas made was 11,820 cubic feet of 16·29-candle power—being approximately three-quarters of a candle power less. But the calorific value is lower; being 530 B.Th.U., compared with 554 B.Th.U. net for the higher quality gas. These results confirm those obtained by others working in the same direction; and they indicate that there is no strict relation between candle power and calorific value, even when the former is ascertained by the "Metropolitan" No. 2 test-burner, which deals fairly with gases of varying candle power.

The author is indebted to Dr. Colman for pointing out, since the issue of the report, that the calculations of calorific values, as ascertained from analyses of the gases, do not agree with those given in Table II.; and that the figures in Table III. appear to be too high by about 7 per cent. A test for aqueous vapour contained in the gas supplied to the town at a temperature of 22° C. gave 1·95 per cent. by volume. Dr. Colman has been good enough to supply the figures from the results of some recent investigations in respect of the calorific values of various gases per cubic foot measured moist at 60° Fahr. and 30 inches of the barometer; these being the conditions to which the gas is corrected in direct estimation by the calorimeter.* From this it would appear that the calculated calorific values from the composition of gases do not quite agree with those actually obtained, and given in Table III., which are the average results of 84 tests by the Junkers calorimeter. The analysis of the composition of the gas obtained from No. 1 and No. 2 retort-houses is the average of three tests of samples taken at the rate of half a cubic foot per hour into the 10 cubic feet test holder on alternate days; the samples being drawn from same into gas sample tubes, which later were analyzed by the Orsat gas apparatus.

* See *ante*, p. 832.

The sampling and testing of gases, although done by an experienced chemist, are difficult matters; and one need not be surprised if the results are not strictly in agreement. The value of investigation work appears to the author to be to give those actually obtained, while discarding results that are obviously inaccurate. Dr. Colman gave on the preceding day the results of his latest investigations in respect of the calorific value of moist gases at 60° Fahr. and 30 inches barometer.

The complex organic compounds which form coal are broken up by the heat prevailing in the interior of the retorts; and during the first few hours of distillation more active gasification takes place, due to the decomposition of the more volatile hydrocarbon matters into gases more or less stable in accordance with the temperature employed. Generally speaking, the higher the temperature that prevails, within reasonable limits, the more completely will those gaseous products first evolved be converted into permanent gases. The destructive decomposition of coal in a hot retort is most complex, and requires further scientific investigation. The gases evolved, and more especially the hydrocarbon series, are split up, and new combinations are formed. These again vary by mutual affinities and reactions of the products, producing an almost endless variety.

Contact for longer or shorter periods with the highly heated surfaces of the retorts plays a most important part; and it is now recognized that prolonged contact is generally attended with injurious results. There is good reason to believe, so far as the production of ammonia is concerned, that the shorter the period of contact with the heated surface of the retort, the less will this valuable bye-product be decomposed; and with filled retorts there is an increase in the production of ammonia, and also a decided increase in the quantity of tar, which is lighter and more liquid.

As regards impurities, sulphuretted hydrogen is so easily and cheaply eliminated by oxide purification that little importance need be attached to its presence in the crude gas; but it is otherwise in respect to bisulphide of carbon, which is a most troublesome and costly impurity to remove. All desire to send out gas containing as little sulphur impurity as possible; and, from observation, the author is inclined to the belief that high heats with more drastic carbonization do not materially affect its production. But there is no doubt that coal containing a high percentage of sulphur means that the resulting gas will be high in sulphuretted hydrogen and bisulphide of carbon. By using a similar grade and kind of coal, but containing less pyrites, it has been found possible to reduce the bisulphide of carbon by more than half, working otherwise under exactly similar conditions. Much may be done by careful selection of the coal carbonized. Special emphasis should be laid on this—that all coal for gas making should be well cleaned from pyrites and other refuse.

All gas-works should, as far as possible, take the fullest advantage of their geographical position in respect to the coalfields. It has been found that, by carbonizing in filled retorts with a longer period of distillation, inferior grades of coal, which happen to be near, can be profitably used for gas making, which formerly were discarded in consequence of their inferiority in regard to coking properties, as by modifying carbonizing conditions a saleable coke can be produced. There is no doubt that more consideration is now being given to this most important of all bye-products of gas manufacture—the fixed residue of coal distillation that forms so large and valuable a product.

In the quenching of hot coke, an excessive quantity of water should be avoided; otherwise quality is deteriorated. It should be borne in mind that its inflammability depends to some extent on the moisture it contains, as well as its size and shape; and an excess of moisture further reduces its effective calorific value.

An extension of the time of distillation produces a harder and less friable coke. That which is in contact with the walls of the retort is hardest; and it gradually decreases in hardness towards the centre of the charge. The crumbling or friability is contingent on the hardness and closeness and size of the pores. It is always, of course, more or less porous in formation; the pores being the passages through which the volatile products issue.

It may be of interest to note that the temperatures given in Table IV.—average mean retort temperature of 995° C., and the combustion chambers temperature of 1332° C.—are both between 5 and 6 per cent. higher than the mean of the maximum and minimum temperatures given early in the report of the Committee on Refractory Materials.

EXPERIMENTS IN CARBONIZATION ON THE BIRMINGHAM COAL TEST PLANT.

By WILLIAM B. DAVIDSON, D.Sc., of Birmingham.

The coal test plant erected on the Saltley works of the City of Birmingham gas undertaking has now been in operation for five years. The installation was described in the "JOURNAL OF GAS LIGHTING" for June 27, 1905.

BRIEF DESCRIPTION OF THE PLANT.

It may be well, however, to briefly recount the leading features of the plant. The retort-house contains four of Waddell's regenerator settings, each comprising six retorts, set in three tiers. The retorts are of ⏢ section, 21 inches by 15 inches, by 20 feet long, and they carbonize, at the high temperatures now employed, 26 cwt. of coal per 24 hours. Only three beds are kept simultaneously at work; and thus the coal carbonized per day approximates 24 tons. The plant is a complete gas-works in itself, and is provided with all necessary apparatus placed in the following order of sequence: There are 6-inch ascension pipes on both sides of the bench, separate hydraulic main to each bed, fitted with Helps's patent anti-dip, retort-house governor, foul main, annular air condensers, water condensers, two rotary exhausters driven by gas-engines, Livesey washer, Holmes' rotary-brush ammonia washer, four purifiers of Green's luteless type, station meter, holder (capacity 240,000 cubic feet), and district governor.

The hydraulic main is fed with liquor from a tank situate above the retort-bench; and a tar tower is used to regulate the seal. Tar and liquor are stored in two underground wells, and measured for sale in two overhead tanks—one reserved for tar and one for liquor.

The regenerators consist of three rows (instead of the usual four) of Waddell's patent tubes; so that the fuel consumption is comparatively high. On either side of the retort-bench, and on the same level as the charging floor, are eight bins or stores, each capable of holding about 20 tons of coal. Seven of these are used to store separate truck loads of coal, which is elevated to the charging-floor in small tip-waggons by hydraulic lifts. One bin is reserved for coke picked from the clinker. Charging, it should be mentioned, is done by shovel.

DEFECTS OF PLANT AND REMEDIES.

On starting the plant a number of defects became manifest. It may be worth while to mention the more serious of these, and the remedies adopted.

1. The retorts were very imperfectly heated. In particular, the bottom retorts were 300° to 400° Fahr. lower in temperature than the top retorts, even when the charges were graduated to give the lowest tier a better chance of gaining in temperature. The first step taken as a remedy was to cut small ports, about 2 inches long, in the spot course between the middle and bottom retorts, and to cut away some of the silica work. This improved matters considerably, but did not tend towards economy of fuel. Eventually, two years ago, the furnace arches and ash pans were lowered some 6 inches, and the furnace itself was modified, whereby the defect was entirely overcome. At the same time, distinct economy in fuel and greater uniformity of heating were effected.

2. The condensers, washers, and purifiers proved to be of unsuitable size during both the height of summer and the depth of winter. This is a natural difficulty with a small installation. It was particularly bad in winter when the temperatures at the outlet of the air condensers and the outlet of the purifiers on occasions fell as low as 36° Fahr.—thus seriously affecting the tests, while in summer tar was carried forward to the ammonia washer. To secure more uniform temperatures, the condensers and washers were enclosed in wooden sheds fitted with folding shutters. The appliances are thus protected from the extreme cold of winter and from the sun's rays in summer; and the results of tests are now comparable all the year round. A further improvement was brought about by the introduction of closed steam into the purifier boxes; but this was an alteration that mainly affected the efficiency of the oxide.

3. It had been intended to use the holder for collecting a day's make of gas for testing, and then to deliver it to the district. This was an unsatisfactory method of testing, and therefore a small holder of 300 cubic feet capacity was provided for the purpose of collecting samples of the gas made every shift.

4. The pressure in the hydraulic main was subject to considerable fluctuation, and a retort-house governor was accordingly installed.

Many minor additions and alterations were found advantageous; but it would be of little interest at the present time to enumerate these.

It is only fair to state that no serious blame is to be attached to the contractors, who were only too anxious to fulfil their contract, and bring the plant into as perfect a condition as possible.

Considerable delay was experienced in coming to a decision with regard to these alterations, and the plant was further handicapped for the first year of its existence by lack of efficient supervision. It will thus be readily understood that two years elapsed before what might be termed first-class results were obtained in the carbonization of the numerous coals submitted to test.

A comparison of the yields obtained from coals tested in 1906 with those obtained from the same kind of coal in 1910 will serve to indicate the progress that has been made. The figures are averages of two tests in each case.

Date of Test.	Coal Carbonized per Retort per Day. Cwt.	Retort Temp.	Yield of Gas per Ton. Cub. Ft.	I.P. Candles.	Multiple.	Fuel. Per Cent.
Coal A. February and March, 1906	22·7	1630° F.	10,350	14·97	154,900	17·0
,, ,, March, 1910	26·0	1910° ,,	11,710	15·36	179,900	18·0
Increase in multiple = 16 p. ct. Decrease in carbonizing wages per ton of coal = 13·0 p. ct.						
Coal B. February and May, 1906	23·0	1630° F.	10,500	14·85	155,900	18·0
,, ,, Dec., 1909, and February, 1910	25·9	1900° ,,	11,320	15·83	179,200	17·7
Increase in multiple = 15 p. ct. Decrease in carbonizing wages = 11·0 p. ct.						

The improvement is indicated in a general way by the results of the year's working—

Gas made per ton reduced to the 16-candle basis, 1905-6	10,530
,, ,, ,, ,, ,, ,, ,, 1908-9	12,180
Increase	15½ per cent.

The net result of the improvement in carbonization, combined with certain other economies of labour, was a saving of over 30 per cent. in the wages per 1000 cubic feet, and this without the addition of any labour-saving machinery.

Comparative Advantages and Disadvantages of Large and Small Test Plants.

For a number of years prior to the inauguration of coal-testing on a manufacturing scale, almost continuous use was made of separate small test plants—one at Saltley and one at Windsor Street works. In one installation, iron retorts were used and clay in the other—taking a charge of 56 lbs. The retort temperature was maintained as nearly as possible at 1620° Fahr.; temperatures much higher than this soon ruined an iron retort. The coke was drawn and weighed in the hot, dry state, when the evolution of gas dwindled down to a rate of less than one cubic foot in five minutes. The gas was collected in a holder of 300 cubic feet capacity, whence it was conveyed to the photometer for testing.

The carbonizing tests were always done in duplicate. If the two results differed by more than 5 per cent. (a by no means uncommon occurrence), a third test had to be made. On the average, the gas multiples thus obtained were in those days considerably higher than works multiples; and, in fact, it was usual to make an allowance of 15 per cent. in favour of the latter.

An unsatisfactory feature was the want of uniformity of the test-plant records. The monthly tests showed very marked variation; and in the light of more recent experience one would be safe in saying that the coal agents were sometimes taken to task for inferior quality when no such deterioration existed. On several occasions, coal sent to the large test plant from the other works of the department, as being much below standard, showed no deterioration in value or even a slight increase.

The following two examples illustrate the degree of variability referred to, the coals compared being the same in both cases:—

Coal "C."

Small Plant. Weight carbonized, 56 lbs.	Multiple.	Large Plant. About 60 tons.	Multiple.
February, 1904	178	April, 1909	206
March ,,	170	July ,,	206
April ,,	148	October ,,	206
December ,,	173	November ,,	204
February, 1905	177	January, 1910	195
Average	169	Average	203

(Difference = + 20 per cent.)

Coal "D."

January, 1906	171	January, 1909	197
,, ,,	181	February ,,	197
February ,,	185	May ,,	199
,, ,,	197	November ,,	200
March ,,	193	March, 1910	195
April ,,	188		
Average	186	Average	198

(Difference = + 7 per cent.)

It may here be stated that the carbonizing results of more recent tests on the large scale greatly exceed those of the small plant in the majority of cases. A few coals show close agreement, while the small plant is superior in only two or three instances. On the other hand, there is concordance in the determinations of total coke made (dry basis). The following are comparative figures:—

Coal "E."

Small Plant.	Total Coke (Dry). Per Cent.	Large Plant.	Total Coke (Dry). Per Cent.
February, 1904	65·5	April, 1909	66·7
March ,,	65·5	July ,,	66·0
April ,,	66·0	October ,,	66·5
December ,,	65·0	November ,,	65·6
February, 1905	65·0	January, 1910	66·2
Average	65·7	Average	66·2

(Difference = + 0·8 per cent.)

Coal "F."

Small Plant.	Total Coke (Dry). Per Cent.	Large Plant.	Total Coke (Dry). Per Cent.
January, 1906	64·0	January, 1909	64·7
February ,,	64·3	February ,,	64·7
,, ,,	64·8	May ,,	65·2
March ,,	63·3	November ,,	64·2
April ,,	63·8	March, 1910	64·1
Average	64·0	Average	64·6

(Difference = + 0·9 per cent.)

With regard to liquor and tar, small-scale tests are, for obvious reasons, totally unreliable, and are therefore generally not attempted.

In the third edition of "Analyses of British Coals and Coke: A Guide to the Purchaser of Coal," many extraordinary returns are given. The weight of coal carbonized is carefully omitted (it is in all probability not more than 2·24 lbs.); but the other figures are usually elaborated in a wonderful manner—often to six significant digits or a would-be accuracy of one in 300,000, that is, 0·0003 per cent. And perhaps I may be allowed to take this opportunity of protesting against the indiscriminate use, in tests of this kind, of over-exact figures, which only serve to defeat their own ends and tend to bring the technical analyst into disrepute.

For purposes of comparison, I quote the results of two coal tests from the treatise referred to (after lopping off a few figures that have no significance), and place alongside them the average figures obtained from five tests carried out on a manufacturing scale on a total of over 300 tons of the same coals:—

Coal "G."

	Make of Gas.	I.P.	Multiple.	Coke (Total). Per Cent.	Liquor Galls.	Tar Galls.
Test quoted	12,100	21·26	257	61·9	16·4 (3° Tw.)	15·2
Bulk test	11,450	17·75	203	66·0	33·6 (10 oz.)	11·7

Coal "H."

Test quoted	12,020	22·24	267	59·4	19·9 (3° Tw.)	17·5
Bulk test	11,130	17·34	193	63·2	40·2 (10 oz.)	11·3

It seems strange at first sight that laboratory carbonization tests of gas coals should be characterized by so great discrepancy and unreliability. It would not be profitable to discuss at length the causes that lead to inaccuracy; but the following might be mentioned: 1. Defective sampling of both coal and gas. 2. Inadequate means of nicely adjusting the pressure in the retort. 3. Erratic condensation of the tar, and consequent want of control over the illuminating power. 4. Dependence on one test (as a rule) for the candle power of the gas, and hence liability to inaccuracy due to errors of instrument, personal error, and weather conditions. 5. Inability to carbonize the coal at high temperatures. In all these respects the bulk tests on a properly equipped plant have the advantage over laboratory or small-scale tests.

Uses of the Birmingham Coal Test Plant.

The large test plant was erected to supply complete and reliable information as to the true value of the different coals

that might be offered to the Department from time to time, and thus enable the Gas Committee to purchase to the best advantage. A second purpose was the carrying out of experiments to determine the best methods of carbonizing coals so as to reap the greatest commercial advantage possible. It was also to be used to check the quality of different consignments of coal, in order to ascertain if the standard was being maintained. Incidentally, the test-works forms a most useful training ground for the young gas engineer or gas-works chemist.

The test plant has been employed to standardize the gas multiple for each class of coal used on the five works of the undertaking. The standard multiples supplied are, wherever possible, the averages of the last five tests—each extending over at least three days, or preferably over one week, and are for this purpose calculated on a CO_2-free basis. The gas multiples obtained each week by the several works are compared with the multiple estimated from the figures supplied by the coal-test plant; and the differences are shown as percentages $\pm$ on a weekly abstract-sheet prepared for the use of the Gas Committee and the Engineers concerned. This system of comparison undoubtedly leads to friendly rivalry among the officers of the Department, and acts as a powerful stimulus to closer retort-house supervision.

The figures for total make of coke are also made use of so as to admit of a more accurate figure for fuel consumption for retorts being recorded on the works' weekly manufacturing report sheet. Formerly the percentage of total coke made was taken as 60 per cent.—a figure that is much too low.

Even under the best conditions, the testing of gas coals does not admit of a high degree of accuracy. This is no doubt due in chief measure to differences in the nature of the coal—such as percentage of moisture, bats, bastard cannel, &c., but also partly to inaccuracies of measurement and testing. Thus it is advisable to use the law of averages to eliminate errors of this kind by repetition of the tests from time to time. Some idea of the accuracy attainable on an illuminating power basis will be conveyed when I state that individual multiples obtained under standard conditions rarely deviate from the average by more than one to two per cent.

We have hitherto had only limited opportunity for purely experimental work in carbonization. Much of the research work is still incomplete, and several of the special tests already undertaken must be repeated before safe conclusions can be arrived at. This paper can, therefore, only deal with certain phases of carbonization, and that only in broad outline.

Valuation of Gas Coals.

As judgment must be pronounced on the results, primarily at any rate, on a purely commercial standard, it will be necessary for me to give a brief sketch of the method and basis of testing and valuation.

Method of Testing.

Coal.—The net weight of coal put into store is ascertained by carefully weighing the railway waggons, full and empty, on a standardized weighing machine. The colliery weights serve as a check, and average slightly under 1 per cent. in excess (partly due to rain). At least 50 tons are required for a test; less than this quantity does not give trustworthy figures for liquor and tar. It is, of course, preferable to carbonize 140 tons—that is, a week's requirements; and this is done wherever possible. The truck-loads are transferred to separate bins in the retort-house. Any residue is reweighed on small steelyard machines. A certain quantity (about 10 tons) is required for "blowing through" between tests. A description of the physical character of the coal is recorded, and the percentage of bats ascertained.

Coke.—The total yield of coke is determined day by day by weighing the charges for a top, middle, and bottom retort with special care at 10 a.m., and weighing the hot coke drawn from these retorts directly into waggons at 4 p.m. The bulk of the coke drawn from the retorts has a drop of about 12 feet on to the cellar floor, striking a shallow shoot on its way. It is there quenched, and picked up with shovels into small waggons and removed to the railway siding, where it is tipped. It is finally forked into railway trucks with twelve-tined forks (1½ inches between the prongs). The coke and unscreened breeze are loaded separately into trucks, which are carefully weighed. The percentage of unscreened breeze, which varies from 10 to 20 per cent., and averages about 17, is probably a fair criterion of the hardness of the coke. Large samples of both coke and breeze are retained for the estimation of moisture, which is carried out in a gas cooker on a sample weighing about 5 lbs.

Coke is fed hot into the furnaces. The coke picked from the clinker is returned to the furnaces and the residual real clinker weighed. The difference between coke and breeze sold (estimated on the dry basis) and the total dry coke made, gives the figure for fuel consumption, which is fairly reliable so long as proper attention is paid to sampling and the determination of moisture. The moisture may vary from 2 to 15 per cent., according to the size of the coke and the method of quenching. Our average is about 4 per cent., and this is the basis used in calculating coke and breeze made for sale from the various coals.

Fuel consumption is one of the most difficult things to correctly gauge in large-scale working, on account of the difficulty of sampling.

When tests are made in a large retort-house, one bed of retorts is usually singled out. In all cases it is essential to maintain the working temperatures without altering the charges. It is an easy matter to get a low figure for fuel by using large charges and high temperatures, especially if no regard is paid to the make of gas per ton, the degree of "burning off" being judged by the eye.

On account of the large quantity of heat stored in the setting, and the consequent lag in the manifestation of the effect of alterations in fuel, charges, &c., the trustworthiness of the figures for fuel is dependent on the test being of sufficient duration.

The quality of the coke made for sale is described as A, B, or C, and the size as I., II., or III. Thus the best and largest coke is designated AI. The bats in a large sample are picked and recorded as a percentage.

Liquor and Tar.—Much difficulty was at first experienced in deriving trustworthy figures from the measurements of the liquor stocks, owing to the irregular shape of the wells, the uncertainty of dipping tests, and the errors introduced in measuring and sampling the contents of washers and other plant. Eventually, the following method was adopted as satisfactory. The various receptacles (including the hydraulic main, tar tower, retort-house tank, and washers) are run off to a well, where the tar and liquor are allowed to separate, and pumped up to the sales tanks to be carefully separated and measured. The receptacles are refilled with water as quickly as possible. Small leakages through cocks, &c., and volatilization losses must be avoided as much as possible; otherwise the yield of liquor is appreciably affected. Continuous quantitative tests are carried out to ascertain the ammonia passing the final washer. This usually amounts to no more than one grain per 100 cubic feet. Any larger amount than this is allowed for. The liquor is estimated on a basis of 10-oz. strength. The amount of tar is estimated under selling conditions—that is, containing 2 to 3 per cent. of liquor.

Laboratory Tests.

The collected samples of purified gas (seven hours' duration) are tested for illuminating power, calorific value, and carbon dioxide. A representative sample of the gas made during test is subjected to complete gas analysis and specific gravity test. Organic sulphur is determined continuously throughout the test. The crude gas at the inlet of the purifiers is analyzed daily for sulphuretted hydrogen, carbon dioxide, and oxygen. Cyanogen tests are made at the inlet of the Livesey washer.

Representative 4-cwt. samples of the coal are stored in bins. Small samples prepared therefrom are subjected to the usual laboratory tests for moisture, sulphur, ash, volatile matter, specific gravity, and (occasionally) elementary analysis of carbon, hydrogen, and nitrogen. Coke is analyzed for moisture, sulphur, ash, and calorific value—the last named by means of the calorimetric bomb.

It may be of interest to submit a tabular statement of the maximum, minimum, and average results obtained for the more important tests of a large number of Midland gas coals as delivered to the Birmingham test plant, the coke obtained therefrom, and the liquor, tar, and gas impurities as found at ordinary carbonizing temperatures.

		Maximum.	Minimum.	Average.
Coal (unwashed)—				
Moisture . .	per cent.	4·7	1·2	2·8
Sulphur (total)	,,	7·3	0·8	3·7
Ash	,,	8·4	2·0	4·6
Volatile matter	,,	43·7	26·7	31·8
Bats . . .	,,	6·0	0·6	1·5

	Maximum.	Minimum.	Average.
Coke—			
Moisture . . ,, .	15	2	4
Sulphur (total) ,, .	10·2	1·7	3·9
Ash . . . . ,, .	13·7	3·5	7·8
Volatile matter ,, .	8·6	1·6	4·4
Bats . . . ,, .	6·4	0·7	2·1
Make . . . ,, .	71	57	65·5
Clinker . . ,, .	8·4	1·7	3·7
Calorific value B.Th.U. per lb.	11,500	14,000	13,000
Liquor—			
Per ton of coal, galls., 10 oz.	40·0	23·0	33·5
Tar—			
Per ton of coal, galls. . .	15·8	9·8	11·8
Gaseous impurities—			
Sulphur, grains per 100 cubic feet	75	19	35
H_2S per cent. by vol. . .	2·60	0·95	1·50
CO_2 ,, ,, . .	3·55	1·20	2·00
HCN lbs. prussiate of soda per 10,000 cubic feet . .	7·0	3·0	5·0

Basis of Valuation.

The relative commercial values of gas coals are readily ascertained from a knowledge of the make and quality of the gas, the weight of coke made for sale, and the yield of liquor and tar, without considering too nicely the results of laboratory analyses of impurities. The following might be considered a fair basis of valuation per ton of coal, at any rate so far as Birmingham is concerned.

Gas.—The product of the yield per ton and the candle power, generally called the multiple, is the criterion of gas production. For a given coal the multiple is constant, or nearly so, within certain limits. Quantity and quality may vary somewhat, but the product should remain approximately the same. In Birmingham the quality supplied is about 16 candles. The make is therefore reduced to a basis of 16-candle gas, by dividing the multiple by 16, and rated at 12·5d. per 1000 cubic feet, a price arrived at by deducting from the average selling price the sum of manufacturing, wages, salaries, wear and tear, and distribution charges, and then reducing the remainder by the percentage of unaccounted-for gas. For each 1000 cubic feet of gas made above or below 11,000, the further sum of 2·5d. is added or subtracted as wages allowance. There is deducted 1d. as the cost of purification for each unit per cent. of sulphuretted hydrogen per 10,000 cubic feet. The weight carbonized per retort per day is usually constant; any appreciable difference is allowed for at the rate of 1·4d. per cwt. per day.

Coke.—The weights of coke and unscreened breeze sold are in the first place calculated on the dry basis. Then 4 per cent. is added for moisture. Coke is rated at 12s., and breeze at 7s. 6d. per ton. Seeing that the smaller and softer cokes find a ready sale for household purposes, differential prices for first and second class are not employed.

Liquor and Tar.—The price of liquor of 10-oz. strength is taken at 0·67d., and tar at 1·33d. per gallon; these being the actual average selling prices over a certain period.

The sum of the values for gas, coke, liquor, and tar is ascertained to the nearest penny. A cheap common coal is selected as a standard of cost price, and the gross values of the other coals are reduced to the terms of this figure to the nearest halfpenny. An example will serve to make the method clear.

Products per Ton.

Coal.	Make Cu. Ft.	I.P. Candles.	Multiple on I.P. Basis.	Make Cu. Ft. 16 Candle Basis.	Coke Sold.		Liquor Galls. 10 oz.	Tar Galls.	H_2S
					Coke.	Breeze.			
					Cwt.	Cwt.			P.c.
No. I. (Standard)	11,700	16·55	194	12,125	7·69	1·53	36·1	11·9	1·56
No. II.	12,050	16·55	200	12,500	9·50	1·26	33·0	11·6	1·48

Values.

Coal.	Gas.	Coke and Breeze.	Liquor.	Tar.	Deduction for Purification.	Gross Value.	Relative Value.
	d.	d.	d.	d.	d.	£ s. d.	s. d.
No. I.	154·4	62·3	24·2	15·8	1·8	1 1 3	10 0
No. II.	160·1	74·1	22·1	15·4	1·8	1 2 6	10 7

Coal No. 2 is worth 7d. per ton more than No. 1. Its actual extra cost, it may be mentioned, was 18d.

A comparison made on lines similar to the above is of great assistance in the purchase of coal. It is hardly necessary to say, however, that it is not conclusive in every case,

Certain coals do not run well in inclined retorts, and others again may yield gas containing too high a percentage of sulphuretted hydrogen for limited purifying capacity, or an objectionable amount of organic sulphur. The quality of the coke is also an important consideration.

Question of Standard of Quality of Gas.

In Birmingham we are still labouring under the disability of the No. 1 argand test burner. Many of our coals have been tested under the conditions of the No. 2 "Metropolitan" burner for purposes of comparison, and having regard to the possible adoption of the new burner at some future date.

A few coals have been found to yield gas of over 17 candles with No. 1 burner, even at the highest temperatures, when working with level gauge.

It would be unfair to impose a multiple standard obtained in this way on a works using a coal of this kind without admixture of poorer coals; and, therefore, care is taken to reduce the pressure in the retorts so as to bring the candle power down below 16½ where necessary. This, as will be shown, lowers the multiple.

Carbonization tests on the large scale indicate a much greater uniformity in the calorific value multiple than is possible on a basis of illuminating power.

When the legal standard of candle power of town gas is reduced to 12 or 14 candles with the No. 2 burner, coals may be valued, so far as the yield of gas is concerned, on a basis of calorific value with (say) 500 B.Th.U. net as standard. Meanwhile the relation of calorific value to illuminating power is a vexed question. It is well known that the latter alters more rapidly than the former; in other words, a given percentage decrease in candle power is accompanied by a much smaller percentage decrease in heating value.

By considering the results of two years' testing of gas obtained from a large number of different coals, and taking the average, on the one hand, of all the tests ranging between 16·5 and 17·5 candles, and, on the other, of all the tests between 14·5 and 15·5 candles, together with their respective calorific values, I find that a decrease of 1 per cent. in the calorific value corresponds to a decrease of practically 2 per cent. in the illuminating power. This is the case with both No. 1 and No. 2 burners.

In this connection it is interesting to consider the effect of each of the main constituents of coal gas on both the illuminating power and the calorific value. On this subject, the information available in technical literature is both incomplete and incorrect, and I have therefore undertaken a series of laboratory experiments with the object of ascertaining the effect on candle power of admixtures of small quantities of different gaseous constituents. The effect on calorific value is already known. The approximate results are given in the following table, and apply alike to No. 2 and No. 1 argand burners used with full flame.

Effect of One per Cent. of Different Constituents on the Calorific Value and Illuminating Power of Coal Gas on a Basis of 540 B.Th.U. and 16 Candles.

Constituent.	Calorific Value. Per Cent.	Illuminating Power. Per Cent.	Ratio.
CO_2 . . .	− 1·0	− 3·5	1 to 3·5 decrease.
O. . . .	− 1·0	− 3·0	1 to 3·0 ,,
N. . . .	− 1·0	− 2·6	1 to 2·6 ,,
Air . . .	− 1·0	− 2·7	1 to 2·7 ,,
CO . . .	− 0·4	− 0·9	1 to 2·3 ,,
H. . . .	− 0·5	− 0·5	1 to 1·0 ,,
CH_4 . . .	+ 0·8	− 0·4	Increase in calorific value = twice the decrease in illuminating power.
C_2H_4 . . .	+ 1·8	+ 10·9	1 to 6·0 increase.
C_6H_6 . . .	+ 6·0	+ 18·0	1 to 3·0 ,,
$C_{10}H_8$ . .	+ 10·5	+ 125	1 to 12 ,,

Note.—Gas *saturated* with naphthalene vapour at 62° F. contains only 0·0085 per cent. by volume of this constituent. The increase in candle power due to this small amount is only 0·16 or 1 per cent.

The figures for carbon dioxide, oxygen, and nitrogen have been confirmed by experiments with the large test plant. It calls for remark, however, that in short trials the effect of the admission of air was not nearly so drastic as was indicated by laboratory tests. This was doubtless due mainly to the fact that the iron oxide underwent a large rise in temperature and threw off certain hydrocarbons—chiefly benzene—with which the water in the material had become saturated. In one instance, the admission of 3 per cent. of air appeared to effect no reduction at all on the multiple.

In experimenting with air it is, therefore, necessary to allow the plant to attain equilibrium before starting the test, and to prolong the trial.

It will be observed that the effect of an admixture of 1 per cent. of nitrogen reduces the candle power by about 2·6 per cent. As it is this ingredient that varies most of all in the composition of coal gas as manufactured in this country, and seeing that the effects of carbon dioxide, oxygen, carbon monoxide, and benzene have all nearly the same ratio, it follows from theoretical considerations that 2 per cent. reduction of illuminating power for 1 per cent. reduction of calorific value the result previously indicated is approximately what we should expect to find.

If the reduction in quality is due to the abandonment of lime purification, the ratio of fall in heating value to fall in candle power will be 1 : 3¼. In varying the temperature of carbonization, the ratio will depend mainly on the alteration in the volumes of methane and hydrogen, and will be uncertain.

In the case of carburetted water gas, where the oil (and hence ethylene) and carbon dioxide are the most variable factors, we should expect to find a higher ratio. As a matter of fact, it is approximately 1 : 5.

Gas Manufactured with Vertical Retorts at High Temperature Compared with the Product of Horizontals Using the Same Coal.

The divergence between the illuminating power and the calorific value standard is brought out in a marked degree when samples of coal gas yielded by two widely different systems of carbonization—such as horizontal retorts on the one hand and vertical retorts on the other—are compared, as under—

Comparison of Gas from Vertical and Horizontal Retorts.

	Verticals.	Horizontals.
Illuminating power (with No. 2 burner)	15·7	15·9
Calorific value	524	506
Complete gas analysis—CO_2	2·50	2·40
O	0·44	0·48
C_nH_{2n}	3·26	3·32
CO	11·80	10·50
H	51·5	46·3
CH_4	26·6	28·3
N (by difference)	3·9	8·7
Temperature of bunsen flame (calculated from above)	2185° C.	2095° C.

The difference in the respective percentages of methane, hydrogen, and nitrogen are noteworthy. One would be inclined to expect a large difference in candle power in favour of the gas from the vertical retorts, on account of the large diminution in nitrogen (4·8 per cent.). This would seem to be counteracted, in part, by the increase in hydrogen and decrease in methane; but it is probably largely accounted for by a deficiency in the benzene content.

Effect of Altering Pressure in the Retorts.

Nearly all the coals tested for valuation purposes have been carbonized at level-gauge. When this is done, it is found that, for the first two hours after charging, the pressure in the retort is positive, and varies from 0·1 inch to 0·2 inch. During the last two hours, the pressure varies from − 0·1 inch to − 0·2 inch, while it is only during the middle period that there is neither pressure nor vacuum. When retorts are in good condition, any considerable alteration of "pull"—say from level gauge to − 0·2 inch—effects only a slight increase in the yield of gas. When the retorts are leaky 2-10ths of "pull" may increase the make by 8 or 10 per cent. through the introduction of furnace gases. "Over-pulling" has also the effect of burning-out and loosening the retort carbon formed in the joints of the retorts, rendering them leaky, and causing the carbonizing system to be over-sensitive to alterations in pressure.

For the reason that they have fewer joints, moulded retorts are, in my opinion, to be preferred to segmented retorts, so long as the quality is up to standard.

Some results of the alteration in "pull" are shown in the above table.

Effect of Alteration of Pressure in Retort.

Coal.	Pressure in Retorts.	Make Cubic Feet per Ton.	I.P.	Multiple on I.P. Basis.	Difference + or − Per Cent.	C.V. B.Th.U. Nett.	Multiple on C.V. Basis.	Difference + or − Per Cent.	Gas Analysis.			
									H_2S.	CO_2.	O.	N.
									Per Cent.	Per Cent.	Per Cent.	Per Cent.
K	Level gauge	11,610	14·80	172	..	..	..	..	..	..	..	..
,,	+ 0·1 in.	11,370	14·80	168	−2·3	..	..	..	..	..	..	..
L	Level gauge	11,160	17·43	195	..	..	..	..	2·50	2·03	0·20	8·5
,,	− 0·05 in.	11,810	15·84	187	−4·1	..	..	..	1·98	2·45	0·50	11·0
M	Level gauge	11,130	16·35	182	..	550	6120	..	2·22	2·13	0·90	7·4
,,	− 0·20 in.	12,400	13·75	171	−6·0	500	6210	+1·5	2·48	3·02	1·58	13·2
N	Level gauge	12,290	15·31	188	..	529	6500	..	1·66	2·22	0·73	8·8
,,	− 0·05 in.	12,940	13·10	182	−3·2	505	6540	+0·6	1·50	2·67	0·75	11·9

Though the illuminating power multiple rapidly diminishes (the effect of increasing the proportions of nitrogen and carbon dioxide), the calorific value multiple, as might be expected, has a tendency to increase owing to lessening the risk of leakage of coal gas into the furnace setting and increasing the speed with which the gas comes off.

Low-Grade Gas.

Further experiments have been performed with the object of imitating the low-grade gas obtained from vertical retorts, with the results shown below.

Low-Grade Gas.

(Same coal throughout tests.)

Make.	I.P.		Multiple on I.P. Basis.		C.V.	Multiple on C.V. Basis.	Gas Analysis.							
							Crude Gas.	Purified Gas.						
	No. 1 Burner.	No. 2 Burner.	No. 1 Burner.	No. 2 Burner.			H_2S.	CO_2.	O.	C_nH_{2n}.	CO.	H.	CH_4.	N. (diff.)
12,590	14·50	15·85	183	200	523	6590	1·87	2·42	0·74	3·29	10·05	45·3	26·8	11·40
12,940	13·10	14·35	170	186	505	6540	1·50	2·67	0·75	3·13	9·48	46·0	26·0	11·97
12,290	15·31	17·87	188	220	529	6500	1·66	2·22	0·73	3·33	9·69	45·0	31·0	8·03

Effect of Retort-House Governor with Seal and Anti-Dip.

To ascertain the best method of working, different combinations of anti-dip, seal, and retort-house governor were tried, with the effects indicated on next page.

A light liquor seal of about half-an-inch gives us thus a distinct advantage over the anti-dip. This, no doubt, comes as a surprise to many. I believe most gas engineers are inclined to favour a dry main or anti-dip. I attribute the loss caused by the type of anti-dip experimented with almost entirely to the circumstance that during the period of discharging and charging a retort (in our case nearly ten minutes every hour) the gas in all the remaining retorts in the bed is subjected to a pressure of at least ½-inch water gauge. The fault lies in the mechanical arrangements, which are such that sealing pressure can only be applied to the bed as a whole and not to single retorts, as in other types of anti-dip.

The gain in working with a governor and liquor seal is

Anti-Dip, with and without Retort-House Governor.

—	—	Make.	I.P. No. 1 Argand.	Multiple.	Diff. + or − Per Cent.	C.V.	C.V. Multiple.	Diff. + or − Per Cent.
Coal O . .	With governor	12,000	16·20	194,400	+ 4·6	543	6520	+ 0·6
,, ,, . .	Without ,,	12,310	15·10	185,900		526	6480	
,, P . .	With ,,	12,030	14·89	179,100	+ 1·8	512	6160	+ 1·0
,, ,, . .	Without ,,	11,810	14·89	175,900		517	6100	
,, Q . .	With ,,	11,500	15·63	179,700	+ 3·9	544	6250	+ 1·8
,, ,, . .	Without ,,	11,610	14·89	172,900		529	6140	
,, R . .	With ,,	11,630	17·00	197,700	+ 4·8	558	6490	+ 1·9
,, ,, . .	Without ,,	12,070	15·63	188,600		528	6370	
	Average of tests				+ 3·8			+ 1·3

Seal, with and without Retort-House Governor.

—	—	Make.	I.P. No. 1 Argand.	Multiple.	Diff. + or − Per Cent.	C.V.	C.V. Multiple.	Diff. + or − Per Cent.
Coal S . .	With governor	11,730	16·86	197,800	+ 2·3	551	6470	+ 0·5
,, ,, . .	Without ,,	11,910	16·23	193,300		541	6440	
,, T . .	With ,,	11,350	17·45	198,100	+ 1·0	568	6450	− 0·6
,, ,, . .	Without ,,	11,680	16·79	196,100		556	6490	
,, U . .	With ,,	12,230	16·74	204,700	+ 3·8	544	6650	+ 0·0
,, ,, . .	Without ,,	12,330	15·99	197,200		539	6650	
,, V . .	With ,,	11,030	16·91	186,500	+ 2·5	567	6250	+ 1·8
,, ,, . .	Without ,,	10,760	16·92	182,000		570	6140	
,, W . .	With ,,	11,200	16·99	190,300	+ 1·1	564	6320	− 0·2
,, ,, . .	Without ,,	11,310	16·65	188,300		560	6330	
	Average of tests				+ 2·1			+ 0·3

Retort-House Governor, with and without Seal.

—	—	Make.	I.P. No. 1 Argand.	Multiple.	Diff. + or − Per Cent	C.V.	C.V. Multiple.	Diff. + or − Per Cent.
Coal *a* . .	With seal .	10,710	16·83	180,200	+ 1·1	560	6000	+ 0·2
,, ,, . .	Without ,, .	10,910	16·24	177,200		549	5990	
,, *b* . .	With ,, .	11,530	16·92	195,100	+ 3·4			
,, ,, . .	Without ,, .	11,970	15·76	188,600				
,, *c* . .	With ,, .	12,120	16·15	195,800	+ 1·5	554	6720	+ 2·6
,, ,, . .	Without ,, .	12,060	16·00	193,000		543	6550	
,, *d* . .	With ,, .	11,350	17·45	198,100	+ 0·2	568	6450	− 0·6
,, ,, . .	Without ,, .	11,630	17·00	197,700		558	6490	
,, *e* . .	With ,, .	12,040	16·69	200,900	+ 1·2	546	6570	+ 0·0
,, ,, . .	Without ,, .	11,920	16·65	198,500		551	6570	
,, *f* . .	With ,, .	12,230	16·74	204,700	+ 2·6	544	6650	+ 2·5
,, ,, . .	Without ,, .	11,880	16·80	199,600		546	6490	
	Average of tests				+ 1·7			+ 0·9

Effect of Temperature with Constant Weight and Duration of Charge, 6 cwt. in 6 hours. Coal "g."

Temp. °F.	Charge per Retort, Cwt. (Average).	Duration.	Gas.					Coke (Dry).			Liquor	Tar.	Gas Analysis.								Sulphur Grains per 100 Cubic Feet.	H.C.N. lbs. Prussiate Soda per 10,000 C. Ft.
			Make. C. Ft. p. Ton.	I.P. Candles.	Multiple. I.P. Basis.	C.V. B. Th.U. Net.	Multiple. C.V. Basis.	Total.	Sales.	Fuel.			Crude Gas.	Purified Gas.								
													H_2S.	CO_2.	Cn. H_2n.	O.	CO.	H.	CH_4	N.		
		H. M.						Per Cent.	Per Cent.	Per Cent.	Gals. 10-oz.	Gals.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent	Per Cent.	Per Cent. (Diff.)		
1630°	5·99	6 0	9,480	17·80	169	591	5610	62·5	49·9	12·6	43·1	12·7	1·64	2·71	4·78	0·48	8·05	40·2	34·1	9·68	16·0	..
1700°	5·98	6 0	10,550	17·10	180	572	6030	61·9	45·8	16·1	42·8	12·4	1·58	2·80	5·20	0·50	9·40	43·3	33·7	5·10	28·0	..
1775°	6·01	6 0	10,960	16·40	180	558	6120	61·8	44·3	17·5	40·4	12·1	1·77	3·00	4·00	0·50	10·10	42·7	34·5	5·20	34·9	..
1855°	6·01	6 0	11,390	16·10	184	545	6210	61·1	42·8	18·3	41·8	11·6	1·83	2·95	3·96	0·85	10·08	41·5	31·4	9·26	39·6	..

Coal "h" with Variable Charge.

1560°	4·99	6 0	8,610	15·62	135	575	4950	68·9	60·2	8·7	33·8	12·6	2·03	2·78	3·25	0·27	7·27	..	..	..	50·3	3·70
1650°	5·64	6 0	8,820	17·08	151	607	5350	69·2	56·2	13·0	..	..	2·53	2·22	3·19	0·56	7·39	..	..	..	52·9	5·29
1800°	6·06	6 0	11,250	15·49	174	567	6380	67·0	48·9	18·1	34·0	13·0	2·50	1·25	3·29	0·51	7·34	..	..	..	58·2	5·91

Effect of Temperature and Value of Products.

Coal.	Temp.	Weight. Carbonized per 24 Hours.	Gas.							Coke.					Liquor. Galls.	Tar. Galls.	H_2S. P. Ct. in Gas.	Value.
			Make.	I.P.	Multiple on I.P. Basis.	Diff.	C.V.	Multiple on C.V. Basis.	Diff.	Dry.			Sales + 4 P. Ct. Moisture.					
										Total.	Sales.	Fuel.	Coke.	Breeze.				
	°F.	Cwt.				Per Cent.			Per Cent.	P. Ct.	P. Ct.	P. Ct.	Cwt.	Cwt.	10-oz.			£ s. d.
k . .	1920	26·0	11,850	15·55	184	+ 3·4	527	6250	− 0·2	64·4	47·0	17·6	8·33	1·45	35·4	10·5	1·61	1 0 9
,, . .	1795	23·7	11,810	15·11	178		530	6260		64·1	46·2	17·9	8·25	1·36	36 5	11·2	1·51	1 0 1
l . .	1900	25·6	11,650	17·20	200	+ 3·6	558	6500	+ 1·1	65·4	50·0	15·4	8·91	1·49	35·5	14·0	2·15	1 2 9
,, . .	1785	24·2	11,300	17·07	193		570	6430		64·3	49·0	15·3	8·75	1·44	32·2	13·0	1·81	1 1 7
m . .	1840	25·6	12,050	16·55	200	+ 4·7	553	6660	+ 1·4	68·0	51·7	16·3	9·50	1·26	30·6	12·1	1·89	1 2 5
,, . .	1735	23·7	12,060	15·82	191		545	6570		68·0	49·8	18·2	8·87	1·49	28·9	11·7	1·47	1 1 2

thus seen to be about 5½ per cent. over the original method of working the plant with an anti-dip but without a retort-house governor. The anti-dip is, therefore, now discarded, and the governor is in almost continuous action.

Influence of Retort Temperature.

The short history of the coal-test plant is conclusive evidence of the great advantages to be derived from high temperature carbonization. The danger limit of retort and combustion chamber temperature which we set ourselves, has been raised from time to time, with continued improvement in the results taken as a whole. With the refractory material at present in use, it is not advisable to exceed an average retort temperature of 2100° Fahr., or a combustion chamber temperature of 2600°. A carbonizing temperature of about 2000°, as determined after the coke is drawn, and a charge of from 6½ to 7 cwt. of six hours' duration, best suits the purpose of making 16-candle gas under the present conditions of the coal-test plant—that is, with oxide purification only. With really first-class fireclay material, it ought to be possible to exceed these limits of temperature and charge, and reap still further advantage. No doubt under ordinary circumstances the costs of maintenance will tend to increase when higher temperatures are used. No such increase has been observed on the Birmingham test plant; but this is probably due to the use of better refractory material.

If the weight carbonized in a given time is small, the yield of gas is increased, and the illuminating power diminished; but there is a gain in multiple. The larger fuel consumption and increased carbonizing wages may, however, render the method unprofitable. It is possible to obtain first-class carbonizing results with direct-fired settings carrying retort temperatures of about 1600°; but the charges must be reduced to 70 or 75 per cent. of normal, with corresponding increase in cost of manufacture, &c.

The internal area of the retort may be taken as a rough guide to its carbonizing capacity, where the section is similar to standard pattern. The gas engineer, it seems to me, has to aim at carbonizing the full quantity per retort per day as set by some standard, and to endeavour to use temperatures high enough to distil the coal to the best advantage.

The following tables contain results of tests carried out at different retort temperatures with and without altering the weight of the charge. The information they contain is of general interest, and needs no further comment.

Alteration in Weight and Duration of Charge.

The experiments conducted with a view to ascertaining the effect of using very heavy charges without altering the retort temperatures to any great extent, indicate a slight commercial advantage for the heavy charge, even when the carbonizing wages are reckoned on a basis of weight per retort per 24 hours, as they are below. The advantage is naturally enhanced with machinery that can deal with increased charges without prejudice to cost.

Effect of Alteration in Weight and Duration of Charge.

(Same coal throughout tests.)

Charge.	Duration.	Weight Carbonized per Retort per 24 Hours.	Retort Temp.	Gas.					Coke.				Liquor. Gallons.	Tar. Gallons.	H_2S.	Gross Value.
				Make.	I.P.	I.P. Multiple.	C.V.	C.V. Multiple.	Dry.		Sales.					
									Total.	Fuel.	Coke.	Breeze.				
Cwt.	H. M.	Cwt.	F.	Cub. Ft.					Per Cent.	Per Cent.	Cwt.	Cwt.	10-oz.		Per Cent.	£ s. d.
5·49	6 0	22·0	1915°	12,250	16·61	204	542	6640	63·4	22·0	6·76	1 52	38·9	12·1	1·60	1 1 3
6·48	6 0	25·9	1955°	11,960	16·51	197	535	6400	63·5	18·5	7·38	1·54	38·3	12·5	1·93	1 1 7
9·59	8 0	28·8	1980°	11,460	17·01	195	552	6320	63·5	16·8	7·32	2·02	38·0	12·6	1·50	1 1 9

A difficulty was experienced in introducing charges of over 10 cwt.; and additional labour had to be requisitioned to get 13 cwt. into the retorts. In the latter case, the tests have so far not been satisfactory, probably owing to the lengthened period occupied in charging the retort. With heavy charges the coke is larger and denser; but the difficulty in drawing it by hand leads to its receiving rougher usage than is usual with normal charges, and thus the percentage of breeze is not reduced or may even be increased.

Effect of Crushing the Coal.

Ordinarily the coal coming to the test plant does not go through the crushers. It was suggested that crushing the coal might have some effect on the products of distillation. Tests on three different coals were carried out to settle this point. The results are given below, and show practically no alteration in the products.

Effect of Crushing Coal.

Coal.	Make Cubic Feet per Ton.	I.P.	Multiple on I.P. Basis.	C.V.	Multiple on C.V. Basis.	—
n	11,130	16·35	182	550	6120	crushed
,,	10,950	16·65	182	561	6140	uncrushed
o	11,720	16·76	196	562	6590	crushed
,,	11,720	16·68	195	563	6600	uncrushed
p	11,930	15·61	186	530	6320	crushed
,,	11,850	15·55	184	527	6250	uncrushed

Stack Coal.

Several valuations have been undertaken of coals that had been stacked and, six months to two years afterwards, picked up. After making allowance for the excess of moisture present in the coal, the gas multiples were in every case slightly lower than the standard. Our tests do not definitely indicate the percentage loss per annum. It would appear to be no more than 2 per cent. It may be mentioned that while the gas value decreased, the yield of liquor increased very appreciably—no doubt the result of the action of water. The coke markedly depreciated.

Stopped Pipes.

Notwithstanding the employment of high carbonizing temperatures, we have experienced little trouble with stopped pipes on the coal-test plant. Two or three coals out of the large number tested exhibited a peculiar tendency to block the ascension pipes; and trouble is also experienced with cannel. Serious difficulty is almost entirely avoided by thoroughly clearing each ascension pipe daily with a long auger. The troubles that arise in some retort-houses are due to over-condensation. When there are two pipes, there is at times a tendency for all the gas to go up one side of the bed. This phenomenon has probably something to do with the blockages, and accordingly the closing of one of the gas-ways has afforded relief in certain cases. It was thought that this expedient might have an adverse effect on the quality of the gas, which has thus a longer travel over the coke. Experiments arranged for the purpose of ascertaining the amount of depreciation failed to detect any.

Comparison of Results When Using One Ascension Pipe.

(Average results obtained from two coals.)

Temp. ° F.	Make Cub. Ft. per Ton.	I.P.	Multiple on I.P. Basis.	C.V.	Multiple on C.V. Basis.	Liquor. Gallons 10-oz. per Ton.	Tar. Gallons per Ton.
One pipe used—							
1805° .	11,200	16·11	181	5540	621	36·6	11·1
Both pipes used—							
1815° .	11,160	16·10	180	5490	613	36·9	11·7

Coke.

It is improbable that gas coke will ever be sold in quantity on a guarantee of calorific value or purity. Size, colour, hardness, or density are the qualities usually considered. But some cokes are poor in appearance and classified as "C III.;" and yet they are, to use common parlance, "A I" for household purposes on account of their ease of ignition and freedom of burning. Their calorific value may be quite satisfactory; but owing to their liability to form

breeze and dust, they are not in favour with the gas engineer. It is tolerably certain that the introduction on a large scale of a new system of retorting, by which a very large and dense coke is made, would not prove an unmixed blessing, as it would tend to spoil the sale of household coke.

The volatile matter remaining in the coke varies according to the retort temperature and the weight of coal carbonized in a given time. This has also an important bearing on the gas production, which varies directly with the amount of volatile matter driven off from the coal, or inversely with the amount left in the coke. The higher the volatile matter, the greater the freedom of burning. Having regard to the desirability of supplying a smokeless fuel which will ignite more readily and burn more freely than ordinary gas coke, it was considered advisable to determine the yields of the various products obtainable from coal carbonized at very low temperature. The data of a large-scale test are set out below, where they are compared with the quantities recovered from the same coal used at ordinary carbonizing temperatures.

Low Temperature Coke.

Retort Temperature F.	Charge.	Duration.	Gas.					Coke.	Liquor. Gallons. 10 oz.	Tar. Gallons.	H_2S.	Sulphur in Gas.	Analysis of Coke.	
			Make.	I.P.	I.P. Multiple.	C.V.	C.V. Multiple.	Sales.					Volatile Matter.	Calorific Value.
	Cwt.	H. M.	Cub. Ft.					Per Cent			Per Cent		Per Cent.	B.Th.U.
1920°	6·5	6 0	11,850	15·55	184	527	6250	47·0	35·4	10·5	1·61	34	3	13,150
1250°	5·7	about 10 0	5,370	20·37	109	607	3260	55·0	24·8	16·4	1·69	31	16·8	13,720

Valuing gas, liquor, and tar at prices already stated, unscreened coke at 11s. per ton (dry) and leaving carbonizing wages out of account, we get the following comparative values :—

	High Temperature. £ s. d.		Low Temperature. £ s. d.
Gas	0 11 11·8	..	0 7 1·5
Coke	0 5 2·0	..	0 6 0·5
Liquor	0 1 11·7	..	0 1 4·5
Tar	0 1 2·0	..	0 1 9·9
Total	£1 0 4	..	£0 16 4

There is thus the large deficiency of 4s. per ton of coal carbonized, to make up which it would be necessary to have a net revenue of 18s. 3d. per ton for the special coke—an almost impossible figure under present conditions—before the process could be as profitable as high temperature carbonization. The material is, however, an excellent fuel for open grates, especially if prepared from a coal low in ash. Though it is only about 5 per cent. higher in calorific value than ordinary gas coke produced by the same coal, it has the advantages of kindling more readily and making a more cheerful fire.

Oxidizing agents—such as potassium nitrate and chlorate—have been recommended as additions to the coal for the purpose of improving the quality of both coke and gas. The small quantity suggested for use (2 lbs. per ton of coal) has not been proved by our experiments to have any material influence on any of the products. Theoretical considerations did not lead one to expect much; but we live in the days of the discovery of radium and other scientific marvels, and one must therefore not be too sceptical. The following were the figures obtained :—

Without Chemicals.

Make.	I.P.	I.P. Multiple.	C.V.	C.V. Multiple.	Liquor.	Tar.	Total Sulphur in Coke. Per Cent.	Volatile Arsenic in Coke. Per Cent.
10,940 ..	16·67 ..	182 ..	561 ..	6170 ..	37·2 ..	12·0 ..	5·8 ..	0·0002

With Chemicals.

11,040 ..	16·28 ..	180 ..	552 ..	6090 ..	38·1 ..	12·1 ..	5·6 ..	0·0002

In a second trial, double quantities were used with another coal. The results of the coke analysis were as follows :—

	Total Sulphur. Per Cent.		Volatile Arsenic. Per Cent.
Without chemicals	2·8	..	0·005
With chemicals	2·9	..	0·005

The author desires, in conclusion, to thank the City of Birmingham Gas Committee for permission to publish this paper; and he expresses the hope that it may afford useful information to members of the Institution even though the names of the coals experimented with are not disclosed.

Discussion.

The PRESIDENT said they were much obliged to Dr. Davidson for his paper, which he knew had been prepared at some inconvenience—the time not being quite so opportune as it would have been later, while it was only recently that he had been asked to prepare it. Their thanks were also due to the Gas Committee of the Corporation of Birmingham for allowing the results to be published; and they would look forward with a great deal of hopeful anticipation to the further experiments to be made there.

Mr. S. Y. SHOUBRIDGE (Lower Sydenham) said he did not propose to say anything with regard to the report of the Carbonization Committee. He would leave this to Mr. Carpenter. But as an old Saltley man, he should like to congratulate Dr. Davidson on his first contribution to the proceedings of the Institution, and to thank him for his interesting paper. The test apparatus he had was probably the largest, if not the most complete, in the world. He had to prepare the drawings for the first test apparatus at Saltley, which had been referred to, and to supervise the erection and the early working of it, which was found to be exceedingly satisfactory, and to be all that was necessary for the valuation of coal and for checking that which came in under contract. It was a ½ cwt. plant, with a cast-iron retort, with which, of course, it was not possible to work at the high temperatures now in vogue; but the temperatures employed were comparable with those in use at that time. He was not at all sure that the newer plant was not too large for the purpose merely of the analysis of gas coal. It must be somewhat expensive to work, if it were needed only for that. But for the more important purpose of research work, such as had been described, it was admirably suited; and it was to be hoped that the Birmingham Corporation would allow Dr. Davidson to pursue his investigation into the many subjects which required it, and which could only be investigated with such a plant as this. It had been the desire of the Carbonization Committee to carry out experiments very much on the lines on which Dr. Davidson had gone; but they had been unable to do so for want of suitable plant. There were numerous points upon which he should like to say something; but, as there would no doubt be many anxious to take part in the discussion, and the time was limited, he proposed only to deal with one point which was rather important. Dr. Davidson said that, when the legal standard of candle power of town gas was reduced to 12 or 14 candles with the No. 2 burner, coals might be valued, so far as the yield of gas was concerned, on a basis of calorific value with (say) 500 B.Th.U., net, as standard. He thought this statement might get to outsiders, and act in a way that might be detrimental to the gas industry, if it went forth that a standard of 500 B.Th.U. was right for 12 to 14 candle gas. At the South Suburban Gas-Works, they had been making 14-candle gas for some time past; and daily tests of the calorific and the illuminating powers were made. He would not trouble the meeting with many figures, but would give the average results of each month for the last six months, which were as follows :—

Date.	Tests.	Average Illuminating Power.	Average Net Calorific Value.	Highest Calorific Value.	Lowest Calorific Value.
December, 1909	26 ..	14·62 ..	496·2 ..	520·9 ..	466·1
January, 1910	26 ..	14·43 ..	505·5 ..	526·1 ..	465·7
February ,,	24 ..	14·54 ..	479·8 ..	493·1 ..	461·7
March ,,	25 ..	14·22 ..	481·1 ..	497 8 ..	467·7
April ,,	26 ..	14·20 ..	489·2 ..	503·0 ..	466·9
May ,,	25 ..	14·20 ..	499·4 ..	514·9 ..	485·5

All the illuminating tests were taken with a No. 2 "Metropolitan" test-burner. It would be seen, therefore, that a standard of 500 net units would be quite impossible to work to under penalties; and 450 was high enough. It was as well this should be pointed out. The gas was coal gas only—showing that with various coals and various conditions, it did not do to accept too high a standard.

Mr. Charles Carpenter (London) said he must apologize for the limited character of the work the Carbonization Committee had been able to undertake; but fortunately one member of the Committee, Mr. Bell, who had read an admirable paper that morning, was able to make some amends for the deficiencies of the Committee. With regard to the work of the Committee, he did not think they set too high a standard in their endeavours; and possibly they might be more successful if their appointment were continued for another year. Before dealing with the work of the Committee, he should like to say a word in praise of Dr. Davidson for the very admirable paper he had read. He commenced by apologizing for lack of interesting matter; but they would all agree that there was not a page which did not contain a great deal of useful and valuable information. It might not accord with all their individual experience, because he had explained how difficult it was to make experiments under comparable conditions. In fact, all experimenters had long learnt to look with more suspicion on records that agreed than on those which did not. The South Metropolitan Gas Company had been in the habit for many years past of using a works making 1,000,000 cubic feet a day in the summer and 2,000,000 feet in the winter as an experimental works. This had gone on for the last thirty years. But, with the advent of inclined retorts, they found a large proportion of the coal could not be tested in the experimental works at all. It was absolutely impossible to test many Durham coals in inclined retorts; so that the works were not as useful now as was originally intended. They had been endeavouring to correct this deficiency by the erection of experimental works. It had been decided to have one setting of tens, such as were in use all over the country, 20 feet long. But there had been a change in the conditions under which coal was now carbonized; and the result of this he thought would put experiments made with horizontals more on an equality with those made on vertical retorts. He alluded to the method which was brought forward by Mr. Bell last year, of completely filling the retorts, instead of leaving a more or less considerable space above the charge. The author had made some experiments with regard to longer and shorter charges; and the defect had been the one to which he drew attention—namely, the difficulty in complying with the requisite conditions when using hand labour. He imagined these retort-settings were regularly charged and drawn by hand. When they had ordinary six-hour charges, hand working was carried out in a very satisfactory way; but with charges of longer duration and full retorts, though it could be done by hand, it could not be done in the accurate scientific manner which was necessary if they were going to base conclusions on the results obtained. They must not be quite led away by the author's experience with regard to charges of long duration, because he did not think he had been able to carry out the experiments under the best conditions. He might be asked what was his authority for saying this (since it was only necessary to read the paper to appreciate the care and accuracy with which Dr. Davidson made all his investigations), and why he set his opinion against the results thus obtained. He did so because they had already carbonized over 1,000,000 tons in full retorts; and there was no doubt a considerable increase in the volume of gas per ton of coal compared with the old method of working—it might be 500, 750, or 1000 feet per ton. There was this considerable increase; and therefore much as he disliked it, he was bound to set his experience against the result of the careful investigation that Dr. Davidson had made. There might be also other advantages which were touched upon; but there was a defect which Dr. Davidson, in his usual accurate manner, had put his finger upon. There was the question of fuel. In considering this, one had to remember that the old method of building retort-settings was designed for six-hour working; and the object of many carbonizers (dating from the time of Mr. West, of Maidstone, when he advocated short charges of four hours or a little more) in those days was to get the coal in and get the gas out as quickly as possible. The trouble with regard to fuel was one which could, of course, be remedied without any great difficulty, and was very largely a question of jacketing the retort-benches. They had lately made an investigation in an ordinary retort-house, to see how much heat was lost by going out of the windows, how much went out in steam, and so on. A large portion of it was lost owing to the fact that due regard had not been paid to the fact that the retort-bench was a construction in which heat was generated, and that it should be the object of engineers to utilize this heat with the greatest possible economy. A great deal depended upon the proper jacketing of the bench. The paper was packed full of interesting information; and a specially valuable part was where Dr. Davidson dealt with the effect of different constituents on the calorific value. His Company had been engaged for a long time in making investigations on this point; but he regretted to say that the information they had, though very full, had not been tabulated. He had hoped to bring the figures with him, but was not able to do so. He again expressed his regret that the Carbonization Committee were not able to do more than they had. But they had done more than appeared in the report; and if it were only for the report which Mr. Bell had made, they would agree that their labour had not been in vain. With regard to Dr. Davidson's paper, when he read the "Journal" on Tuesday night, he had in his mind some idea that one of the fundamental functions of an engineer was in danger of being overlooked. The American definition of an engineer was well known—a man who could do with a dollar what others took two in doing. But there was another way in which they could put it. In his work, he had raw material given to him—it might be steel, or it might be, in the case of a civil engineer, concrete or brickwork—and he had practically to turn it into gold. In the case of the gas engineer, his raw material was coal; and he would be best judged to be an able engineer who was able to get from his raw material the largest proportion of gold. They could only hope to do this by careful and accurate research made in the manner in which Dr. Davidson had conducted affairs for the Birmingham Corporation. As long as the Institution could depend on men coming there and reading papers of this kind, giving the results of their experience and the way they had worked, they need have no fear as to the future of the Institution or of the industry.

Mr. John West (Manchester) said he had been much pleased with the further researches of Mr. Bell; and he must congratulate him very much on the work he had been carrying out and the results he had obtained. There were some points, however, which he could not quite understand. In Table III., he did not entirely follow his analyses; and he should like to know if he could give any reason for some of the differences between the eight-hour and the twelve-hour charges in the analyses of the gases. He referred particularly to methane and nitrogen. In the nitrogen, the difference was very great—in the twelve-hour charge, it was 6·60 per cent., and in the eight-hour charge 11·10 per cent. He did not know how this considerable difference was to be accounted for. There was also a slight difference in the methane. As vertical retorts had been referred to by Dr. Davidson, he might say that they did not have these difficulties with them. They got a very small percentage of nitrogen—only 3·9; and he thought, if this question were looked into more carefully, it would account to a great extent for some of the large volumes of gas per ton of coal which were talked about by some engineers at some works. Dr. Davidson referred to low-grade gas being made from vertical retorts; but this was not essential. He could make whatever gas he was asked for. The question was, What did they want? Since he last spoke on this subject, he had made more practical experiments probably than most men in the room; and he had been endeavouring to see what could be done. They had varied illuminating power with different coals and cannels, from 13-candle to 20-candle gas, tested sometimes with the No. 2 burner and sometimes with others. He merely desired to know what they wanted. He had a word to say on the question of illuminating power, which was a very important public question. They had now a No. 1 burner and a No. 2 burner; and he did not know how many burners he had been asked to test, and to bring the gas down to, or up to. In his view, all gas should be tested by one burner; and then people could draw their own conclusions and deductions. One gentleman said to him: "That looks all right; but I am under restrictions, and my restriction is not like yours. My gas has to be tested by a No. 2 burner, or a D burner, or an F burner." He was asked the other day to test gas with an F burner. He looked about him, and at last he communicated with a friend or two, and asked what was the F burner. He remembered it in the olden days; and he found it was a burner for testing the Preston 20-candle gas. Of course, this was not suited for testing gas as generally made from horizontal retorts. What he himself advocated was that they should have gas of reasonable illuminating power, and of fair

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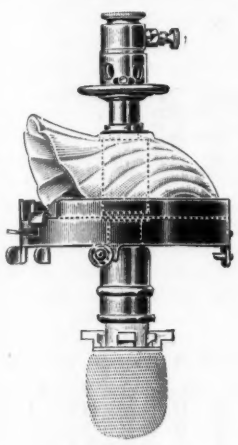

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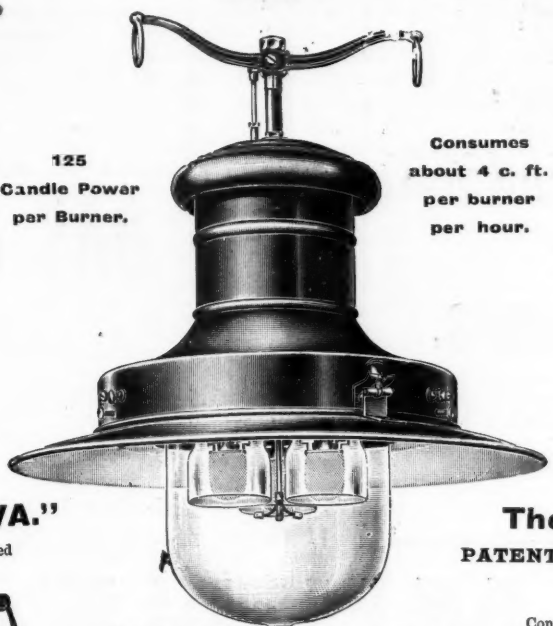

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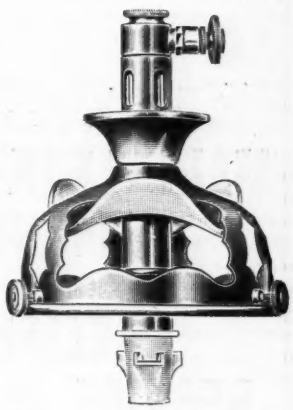

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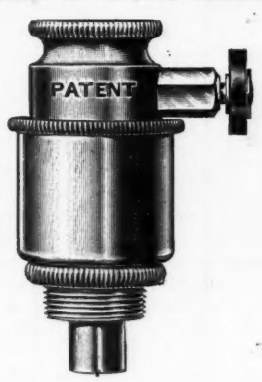

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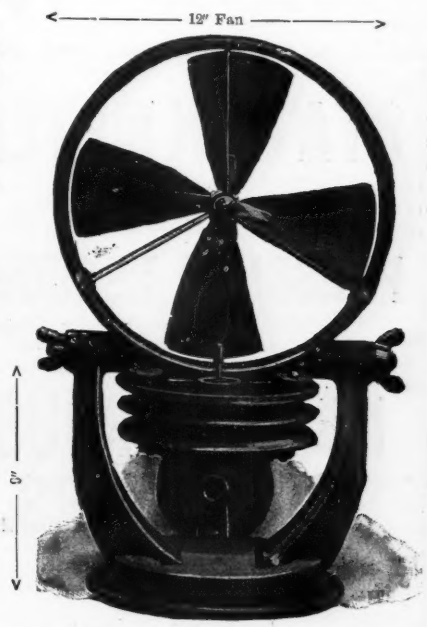

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calorific value. He did not want to be bothered with all these various burners; he had been more bothered with them than with anything else. They were made of various kinds to meet conditions in various localities; but why should there be all this trouble? There were the same kind of people in all the different towns; and there ought to be one rule among them—one kind of instrument to test everything that was supplied. He suggested that they should do away with this burner altogether, and give up all the modes of testing with different kinds of burners, and take the calorific value. This would overcome the personal element. They could not agree in testing very often to a ¼ candle; and some people could not even agree within 2 or 3 candles. Where there were different burners in use, they could not agree at all. But with the calorific instrument, there were no optics involved—no personal element. If the instruments were all right, they could test continuously, minute by minute, or hour by hour, throughout the day. He wanted it to go forth that gas engineers, supplying the public to the best of their ability, did not want any longer to be hampered with these rigid restrictions. They were advancing as they went on. Mr. Carpenter had reminded him that at one time he was a "thin" man, and that he went in for thin charges. He had now grown stouter as he grew older, and he went in for thick charges. Now they had them very thick. A man like himself, trying to please many people, would like to fit himself to keep up with the demands. To-day they were going in for thick charges—it did not matter whether it was in horizontal retorts or in vertical retorts—but he did want this wretched burner question got rid of. As regarded Dr. Davidson's paper, it was most valuable. They were all endeavouring to do their best to arrive at the truth; and he believed as they went on they would get somewhat near to it, though they never would attain finality. Some of the ideas being carried out in Birmingham were, no doubt, very good. They had advanced as time went on; and they had now an apparatus which he very much believed in. They worked continuously day by day trying to get as near as possible to actual working conditions. He understood Dr. Davidson to say that they got within 3 or 4 per cent. of what was done in ordinary works. This was a very great thing. It was of much assistance to the practical men who had to carry out the daily routine in a large retort-house. In his experimental works, he said he was somewhat afraid as to the liability of the retorts to give way. But why should he be bothered with this sort of thing? Have better retorts, so that they could apply some heat to them. Have the best retorts they could get, paying a reasonable price for them—for they would not get a good retort cheap. With those they were using in vertical settings, they took care that they would bear the strain of any heat which could be placed upon them. All the material he used was burnt off in ovens at 2800°. This was more than could be applied in settings; so that they need not trouble about burning them out with any heats in ordinary working. He thought that if they applied these special experiments which had been carried out by Dr. Davidson to ordinary working, they would gradually go on progressing.

Mr. George Helps (Nuneaton) said the matter he wished to speak upon was the question of the anti-dip, the dry main, and the retort-house governor. Six years ago, when in that very room, two or three gentlemen then present ventured to suggest that 12,000 cubic feet per ton could be produced, there were some who jeered. But since then enormous strides had been made, and probably in every works represented there the makes had increased by 800 or 1000 feet per ton. His authority for these figures was the published returns of those works which appeared in the various analyses in the Technical Press; and Mr. Brearley only last week pointed out that the make per ton was not of large importance. Most of them had doubtless looked into this. Mr. Brearley suggested that some of them should endeavour to find a factor which would govern all the complex issues with regard to the carbonization of coal, and arrive at a value for it. Dr. Davidson had done him (the speaker) the honour to mention in his paper the hydraulic main with which he had something to do. He could only thank Dr. Davidson for the very fair, honest, and honourable manner in which he had put this aspect of the case before the meeting. When he first looked into the question, he was struck by the results obtained by Mr. Paterson, of Cheltenham, whose absence that day all must regret. For a number of years, he had been making 11,500 to 11,800 cubic feet of gas per ton of coal, and doing this with a dry main. Then he looked into the matter for himself. He thought, if Mr. Paterson was making 11,800 cubic feet, why should not he; and he came to the conclusion that the dry main was the thing. Then he set out to discover whether in his own case he could not fix up something which would give a similar result to a dry main without using several valves. The result was the anti-dip which Dr. Davidson spoke of. Dr. Davidson said that he had done away with the anti-dip because he had discovered that with the retort-house governor he got 5 per cent. better results. He need hardly say that no personal interest of his had anything to do with what he said on this matter. They would all of them give him credit for endeavouring to be honest, whether he was or not. He cared nothing for any monetary consideration which he might receive for hydraulic mains or anything else. What he cared most for was their good opinion. He need not apologize for dealing with this question of the anti-dip. Dr. Davidson had placed it before the meeting as fairly as he could have done it himself. Apart from his (the speaker's) own personal interest in the matter, he might say there were other big works using this anti-dip. For instance, at Sheffield they had been experimenting with it for some time; and they were now setting out to adopt it throughout their works. He did not know how many million cubic feet they made. If they asked Mr. Berridge, of Leamington, to show them his pocket-book, they would see a jump up of some 800 or 1000 cubic feet when he adopted the system. This result might not be brought about by his dry main. It might just as well be secured by a retort-house governor or the dry main in some other form. But Dr. Davidson said there was a lot of oscillation. He might have done away with that. They knew that if there was oscillation in a main, they were not getting as good a make as they could without it. He also said that he used a ½-inch seal while they were charging the retorts. This ½-inch seal need not have been put on. He need only have put on the seal which he put on with the retort-house governor, and then he would have found there was a better result than he had shown. Again, the anti-dip arrangement could be set or made to seal each ascension-pipe; there was no question about that. Dr. Davidson did not tell them what was the make per ton per annum in Birmingham. There were a lot of works where good makes were got; and perhaps his reason for not mentioning it was that they had not yet any part of their plant built on the lines on which he would now build it after the experiments he had made. He thought he might therefore justly ask them not to consider the question whether the anti-dip was a good thing or not, but to consider whether the case was so far proved.

Mr. Arthur Valon (London) said that he was inclined to think they were back again in the Victorian era, and that the intervening ten years were forgotten. He found that the Birmingham Corporation were working to multiples founded on the make of gas multiplied by the illuminating power; and it was an illuminating power of 16 candles measured by the No. 1 "London" argand. If only a big corporation like Birmingham would take the lead in obtaining a calorific standard in place of the old illuminating standard, he believed they would do more for the industry than probably any other action they could take. A corporation could do it much more easily than a gas company, because they were free from opposition in their own borders. But they not only still worked to an obsolete standard, but apparently they made it a matter of competition between the engineers in different works. This might be all very well; but he did hope the example would not spread. It might be all right if corporation committees were composed of technically qualified persons. He did not know anything about the Birmingham Gas Committee; but as a general rule this was not so, and consequently they could not make the proper allowances which could, and must, be made if engineers were going to be judged by such a thing as a multiple figure composed of the make and the illuminating power of the gas. Dr. Davidson showed himself that the standard was quite illusory. He said that, in a case of using coal which gave a gas of 17 candles, care was taken to reduce the pressure in the retort so as to bring the candle power down to below 16⅔ where necessary. Apart from the question of whether this was a wise way of reducing the illuminating power, the engineer, if using a particular kind of coal, was bound to lower his multiple for the sake of the economical result of his working; but he would still show badly in the returns

in comparison with other people. He was glad to see Dr. Davidson had discovered that 12 cwt. of coke was lower than the average amount made. It was a very common figure; but there were few coals which did not give more. This figure was probably responsible for the many somewhat miraculous fuel accounts which one heard of. Dr. Davidson gave a method by which they ascertained the relative value of coals in Birmingham. The figure as it stood seemed fairly correct, and he presumed it was correct; but it had this drawback—it would appear that if they had two coals and the value of one was higher than the other, the one with the higher value would be the better one to use if the prices were the same. But this did not follow necessarily. They did not work to a definite number of tons of coal carbonized. The number of tons of coal carbonized was limited by the quantity of gas they had to make; and it was quite possible to get a coal which would show a higher value on that system, because of the increased yield of gas, but, owing to the fact that under these circumstances they would use a less number of tons, the result might be that the total profit—owing to the small amount of residuals—would be less than if they used a coal which showed a lower value. It seemed to him that the proper way to deal with value was to take it per 1000 cubic feet of gas sold, which was, after all, what they had to look at. If this were done, deducting from it the returns for residuals, they would get an absolutely comparable figure.

Mr. W. B. Randall (Waltham) wished to add his meed of thanks to Dr. Davidson for his admirable paper. Unlike him, he could not profess to be a gas chemist; but he did think that in a small place, such as he had the honour to serve, they could make the works, if not an absolutely experimental works, very much like them. For this reason—that in a small works they could devote a great deal of time and attention to the everyday practice of the retort-house especially; and they could have the pleasure and the benefit of following such a remarkably good paper as that given by Mr. Bell last year, which undoubtedly had caused a great revolution in carbonizing throughout the country. He was not able to be present at that meeting; but when he read the paper, he thought to himself, here was something better in store than he had been able to get so far. For several years, they had been working with six-hour charges; and when he found that Mr. Bell said they could get 13,000 cubic feet per ton, he wanted to know why he should not also get it. Mr. Bell was very kind in answering several inquiries he made of him, which he was afraid must have been a great tax on his time, and possibly on his temper. But he must say that, having tried first eight, then nine, then ten, and then twelve hour charges, he was pleased to be able to tell them that, as the result of several months' working with twelve-hour charges, Mr. Bell's prophecies were fully verified. They were able to make over 13,000 cubic feet per ton of coal, and to sell about 12,500 cubic feet; and with this they had a far less number of complaints from consumers than they had previously. The reason for this was that they were able, to a great extent, to free themselves from the bugbear of naphthalene, owing to the twelve-hour charges. If only on this account alone, he thought they would find that the method of filling-up the retorts as far as possible was undoubtedly a good one, and would give them the very best results; and he would remind them that they were the stewards of every ton of coal they had to handle. Reference had been made that morning to an article in the Technical Press relating somewhat to "The Top of the Tree;" but he would like to point out that if that were carefully scanned through, they would find that the way the author took it was purely a matter of geography. If they were able to buy coals at 10s. a ton, and to sell the residuals at 7s., it was not a very difficult task. They must not for a moment be led away by figures of selling prices. Where they in the South had to pay on Yorkshire coal 8s. to 8s. 2d. or more per ton for freightage, they could not afford to use slack, and pay such an enormous cost of carriage. Therefore it was not right to get out a table showing a cost of 10s. a ton, and compare it with other people who had to pay 20s., as shown in the diagram. With regard to the question of high makes, undoubtedly they had to look forward to a much greater yield per ton than they ever did before; and in the "Journal of Gas Lighting" on the previous day, he noticed it mentioned that, whereas 8000 cubic feet per ton was the usual figure in "Field's Analysis" of the London Gas Companies when first started, it had now gone to 11,000 feet per ton. If they could only imagine the thousands and thousands of pounds which this meant financially to the gas companies, Mr. Bell would feel that all the time and labour he expended on his paper, in pointing out a method by which they would be able to fight all opponents and keep themselves and their companies quite at the top of the tree, had been well spent. Dr. Davidson also mentioned that there was an art in selling coke; and there was not the least doubt about this. With these heavy charges, they produced a coke which was far superior to that produced with six-hour charges. He had some coke from Norwich, which was a magnificent sample; and there was no question that coke users would give 6d. to 1s. a ton more for such splendid, close grained and hard, dense coke as could be obtained with heavy charges. Again, they were met in their district with trainloads of furnace coke from Yorkshire and Derbyshire, which was being sold now at practically the same rate as they were able to get for ordinary gas coke. It was a good coke, for he had had truck-loads of it and analyzed it. It contained only 6 per cent. of moisture. It was a first-class coke; and unless they produced a good coke, they could not possibly fight it. They must therefore alter the system of carbonizing so as to produce a good coke, in order to compete with this furnace coke. Mention was made about high yields being due to anti-dips, dry mains, retort-house governors, &c. They had these adjuncts in the retort-house, and he gave them credit for all they were possibly worth; but he thought they were rather inclined to be overrated. If the temperature went down, the make went down; and a retort-house governor, anti-dip, dry main, or anything else, would not bring the make per ton up again. They must keep the temperature high; and, as one of the benefits from the carrying out of the investigation with regard to refractory materials, he might mention that the Fèry pyrometer had helped him very considerably to find out how it was they got a much better make. He had no hesitation in saying that what was wanted was high makes. They wanted a temperature of 2000° in the retorts when they were drawn and ready for charging. They could get it in the retort immediately over the producers. It was the lowest retorts that broke them down. But if they could get them to 2000° all round, and heavy charges, there was not the least reason why they should not rise to 13,000 or 14,000 cubic feet per ton of coal carbonized.

Dr. Harold G. Colman (London) said he wished shortly to express his hearty thanks to Mr. Bell and Dr. Davidson for the very valuable papers they had given. With regard to Dr. Davidson in particular, he thought they would be only able to fully appreciate his paper when they had time to study it. He had read it through two or three times; but the tables wanted more study than one could give them in that busy week. The special point which came out in Mr. Bell's paper was that the illuminating power multiple, as represented by the sperm value, was 2·3 per cent. better in the case of eight-hour charges than with twelve hour; while with regard to the calorific power multiple, there was nearly 6 per cent. advantage with twelve-hour charges. This was, of course, a matter of the utmost importance at the present time, when they were really in a transition stage, and did not know whether they had to work to calorific power or to illuminating power. At present, they had, unfortunately, owing to statutory restrictions, to confine themselves entirely to illuminating power, or at any rate, to give their main attention to this, though they knew they would be doing better if they devoted their chief attention to the calorific power. The question he wanted to deal with was, How was it they got these differences with the full retort? And what he was saying applied equally to all forms of retort, whether fully charged or nearly fully charged, horizontal or inclined retorts, or vertical charged intermittently or continuously. It was the fact that in almost all cases one got an increased yield of gas combined with an increased yield of tar. This increased weight of gas and increased weight of tar must have come from somewhere; and the point was, Where could they have come from? They knew that in most cases they had not come through a larger amount of furnace gases being pulled in, because both with full charges and with the vertical retort the gas produced contained far less nitrogen. It must therefore have come in some way from the coal. Either there must be less weight of coke produced or there must be less water formed and condensed from the coal. Very unfortunately, these two points—the amount of coke produced and the amount of water formed—were the most difficult to obtain accurate figures for on a large-scale or even a small-scale working. But he was

convinced that in all these cases the improved results obtained from the points of view of gas and tar came largely from the fact that the steam which was formed from the coal was decomposed to a greater extent when the retort was fully charged than was the case when there was a large free space over the coal. Why this was so, he was not prepared to say; but he thought the increased yield of gas was more due to this source than that which Dr. Davidson mentioned. He quite admitted that a considerable amount of hydrogen was given off from the coal by further heating; but this would not account in any way for the increased production of tar, because the gas given off at this stage from the coal gave practically no tar at all. This was one point which required investigation. They wanted to know what part the steam took in the carbonization. He was not referring merely to the steam given off from the coal which was originally present in it as free moisture, because probably this went off for the most part at a fairly early stage. He referred to that which was produced and carried away through the whole period of carbonization by the decomposition of the coal substance, which always contained a large percentage of oxygen. Taking the coal analysis Mr. Bell gave in Table I. of his paper, they would find the oxygen, apart from moisture, was 7·3 per cent. If all this oxygen could be converted into gas (which was theoretically impossible), they would get from the coal a yield of 20,000 cubic feet per ton—though not of high calorific power. At present, under ordinary circumstances, they converted roughly only about one-fourth of the oxygen into gas; the other three-fourths came away as virgin liquor. Therefore, there was a considerable volume which they could probably obtain as gas by the interaction of this steam with the other vapours. They were apt to look on steam as an inert substance like nitrogen when it was mixed with gas. It was so at a low temperature; but at a high temperature, it was a very re-active agent. And undoubtedly there were changes going on—not merely the action of the steam on the coke producing the water gas with which they were familiar, but there must be an action going on between the steam and the other gases, including the tar vapours, which were present in the retort. They seemed at the present time to be in complete ignorance of what was happening in this respect. If they could, by the investigation of any forms of carbonization, get further information in this respect it would be a very material help in getting at what they were all aiming at—the greatest number of thermal units present in different coals into the gas obtained from that coal. There was one point in Dr. Davidson's paper which at first sight seemed to contradict what he had just said. Mr. Carpenter had referred to it already, and it was that in the test plant at Birmingham, so far as they had gone at present, the heavy charges had not given the same results as had been obtained in other places. This was probably largely due to the conditions. But it seemed to him, looking at the figures, that one reason was that the period of carbonization was not sufficiently long, in the case of the 9½ cwt. charge, to carbonize the coal to the same extent that it was carbonized in the 6½ or 5½ cwt. charges. Contrary to experience in most cases, with the increased rate of charge there was nevertheless a great deal more coal carbonized per retort in the 24 hours; whereas, if they took Mr. Bell's figures, the make per mouthpiece came out much about the same or a little higher in eight-hour charges. He thought probably this accounted for the difference; and, in addition, there was the point Mr. Carpenter raised, that the hand charging with these heavy charges did not give quite comparable results with those obtained by machine charges when using 9 cwt. or more.

Mr. Charles Hunt (London) said Dr. Colman had raised one or two interesting points. It always appeared to him that the increased yield resulting from heavy charges in full retorts had been due, not to the rise of temperature within the retort, but to the reverse. His experience was that, with moderate heats, they got more gas and more tar than with high heats, as they were called. If they filled a retort with coal, the retort must be at the commencement somewhat higher in temperature than would ordinarily be the case; but the bulk of the gas coming from the coal met a lower temperature, and was consequently not decomposed to the same extent as it was when there was a large free space above it which it had to go through. This, he thought, accounted for the increase of the tar at the same time as there was an increase of gas. Dr. Colman appeared to think that a great deal depended on the decomposition of the steam, if he understood him rightly; but, in fact, he (the speaker) understood that with a filled-up retort they obtained a larger quantity of virgin liquor than with a partially filled retort. If this were so, it rather disposed of the question which Dr. Colman raised. The papers were admirable contributions to the subject of carbonization; and their thanks were due to both authors for the excellent manner in which they had been prepared.

Mr. Samuel Glover (St. Helens) said Mr. Hunt had touched on a matter which was of considerable importance in this connection; and he should like Dr. Colman to take a note of this point in Mr. Hunt's remarks, which he was quite sure from his experience of carbonizing coal in different ways was a very important one. He would suggest that considerable difference in the value of coals carbonized scientifically was obtained by the fact that there was less breaking-down of the hydrocarbons than in the ordinary method of carbonizing with partially filled retorts. The method of working either horizontal or inclined retorts which was being followed at the present day, imitated as nearly as possible the practice which obtained in vertical retorts; and the improvement was partially due to the fact that there was less breaking-down, and therefore less loss, of the hydrocarbons originally contained in the coal. The carbon on the retort was very much less in vertical than in the old-fashioned horizontal or sloping retorts. There was also very much less stoppage of pipes, and no pitched-up hydraulic mains. These were the places where some of the differences would be found. It had often been explained that "muck" was only matter in the wrong place, and the pitch in the hydraulic main and amorphous carbon or pitch in the ascension pipes, and a large production of retort carbon in the retort, was only muck, because it was matter in the wrong place. They got a very much better result from vertical retorts—especially those worked continuously—because the conditions were such as helped to bring those results about in the very best scientific manner.

Mr. J. P. Leather (Burnley) said he hardly thought of taking part in this discussion; but one or two points had been raised by Dr. Colman and Mr. Hunt which tempted him to say something. He did not think he could say anything at present in the way of narrating his experience of the work he had in hand; but he promised that as soon as he had anything worth bringing before them he would endeavour to do so. Dr. Colman told them that by the modern methods of carbonization they were getting more gas per ton and more tar; and Mr. Hunt said also they were getting more liquor. He (Mr. Leather) did not know whether they were getting more coke per ton; but somehow or other, if all these things were found to be true, they must be getting more than 2240 lbs. from a ton. He thought there was considerable weight in the hint just thrown out by Mr. Glover with regard to the carbon on the retorts. He did not know that he had seen much said anywhere, either in contribution to the proceedings of the Institution or in any of the Technical Journals, as to the amount they really lost by carbon on the retorts; and it was rather difficult to say what this actually amounted to. If they liked, they could all find out how much retort carbon they sold per ton of coal in the year; but this did not represent the real loss by carbon deposited on the retort—particularly on a retort which was frequently open to the air—and consequently a fair proportion of the carbon deposited upon it was burned away, and did not come into money in the way of selling retort carbon. An amount of only 2 or 3 lbs. of carbon (and he had not the slightest doubt that in many cases they did have a deposit on the retort of more than this amount), meant a good deal when put into the form of gas. If they calculated it out as marsh gas, the quantity did not need much hydrogen added to it to make a considerable volume of marsh gas. If in vertical retorts, for instance, they got considerably less carbon deposited, or in fully charged retorts, horizontal or inclined, there was not so much deposited, this would account for some portion of the gain. The point thrown out by Dr. Colman with reference to oxygen was certainly worthy of investigation; and he was very thankful to him for the hint. It was a point which he would endeavour to investigate in the work that he hoped to carry out on the vertical retorts which he had now in use in his works.

Mr. P. C. Holmes Hunt (Melbourne) said this subject was one with regard to which he had come from the other end of the earth in search of information for his Board, in order to recommend to them what installation should be put

up in the new retort-house they were going to erect at an early date. In looking over the work which had come before the meeting, he felt that nothing was of more importance than that brought forward this morning; and if he expressed some slight regret at not finding more information from the Carbonization Committee, perhaps the explanation of his mission there would be taken as a sufficient excuse. He must say that he had looked forward to something more with regard to vertical retorts and full charges than had been produced. On the latter point, he could only say the experiments and work which they had carried out in Melbourne confirmed, to a very great extent, the very excellent work Mr. Bell had brought before the meeting. They had in Melbourne to deal with classes of coal which varied considerably; and unfortunately they found that one class which swelled considerably in the retorts did not yield such good results, under what he ventured to term prolonged carbonization, as the coal which did not swell. For this reason, he had been forced to regard the old section of retorts, 21 in. by 15 in., or thereabouts, as a "back number;" and he could not, from what he had done, see how anything but a very large section of horizontal retort could be used in future to get good all-round results. He would like to ask Mr. Bell what was really meant by "full charges." He took it the system of working which he had brought forward, of 12 cwt. in an 18-foot retort, was a charge right up to the roof of the retort, though there might be a gas passage left at the top of the charge sufficient to act as a duct to convey the gas to the ascension-pipe. In Melbourne, they had found that, when they attempted to work with a full retort, jambing the coal right in, and packing it, they got undue pressure in the retort. To relieve this, a second ascension-pipe might be put in. In their new installation of 160 retorts, they had single ascension-pipes on the charging side of the bench. If they did not attempt to cram the retort right up to the roof, but left a little passage over the charge for the gas to get away, they did not get this pressure, and obtained a result very far in excess of that secured from eight-hour working. With a good coal, they got at least 500 cubic feet per ton more under this system than with the eight-hour working. It appeared to him it was a point on which they would like some more elucidation, as to whether the horizontal retort was better worked packed full or with a gas passage left on the top of the charge. To him it appeared that there was one great advantage in working with a single ascension-pipe; and, though he was open to conviction, he should require a great deal of proof that a second ascension-pipe was essential to the working of horizontal retorts. Having only one simplified the labour and cheapened it; and in his part of the world this was a great consideration.

The PRESIDENT said there had been a most interesting discussion on these papers; and attention had been drawn to several important points. When Dr. Davidson was speaking of the Birmingham testing plant, he could not help thinking what a pity it was that this plant did not belong to the industry generally. That was something he looked forward to, and still hoped to see some day. It seemed hardly fair and just that one broad-minded Corporation should put down a plant of this description, presumably to test their coal for the purpose of purchase, but really to carry out researches which were available for the industry generally, but to which the industry did not contribute anything in the way of financial assistance.

Mr. BELL, having thanked the members for the reception given to the Committee's report, said the paper he had read was rather a supplement to that report; and he was indebted to them for allowing it to be brought forward. One gentleman had referred to him as the pioneer of heavy charges; but he really thought the Chairman of the South Metropolitan Gas Company, Mr. Carpenter, was the actual pioneer. He believed he started filling up the retort before they did at Derby; and the only thing was that he (Mr. Bell) happened to bring forward the first results. It was only proper, however, to recognize the part Mr. Carpenter had taken in this matter. In regard to the question raised by Mr. West as to the large quantity of nitrogen in the gas (as given in Table III.), it seemed to him that probably this arose from some disassociation of the ammonia. In No. 2 retort-house, he had anti-dip valves on the dip-pipes; and it might be that during the last two or three hours of the charge, when there was little gas coming off from the coal, there was a slight vacuum on the retort, which would bring in a little nitrogen. Since this investigation had been carried out (and it proved the advantage one got from carrying out these investigations), during the last three hours they closed the anti-dip valves, so as to keep a pressure of about ½ inch on the retort. He congratulated Mr. Randall on being able to get 13,000 cubic feet per ton; and he thanked him for his testimony. What brought to his mind the advantages of these heavy charges was that those who were near the coalfields could use lower grades of coal which formerly they discarded; but those further away, who naturally had to pay a higher rate, used higher and better grades. With regard to Mr. Leather's remarks on the carbon on the retorts, his own experience, though he did not like to dogmatize on these matters, was that there was less carbon in full retorts. Also with reference to the sulphur and the naphthalene, he did not know what Mr. Carpenter would say about that; but he was inclined to think they did produce less sulphur, less naphthalene, and less carbon with full charges. He was glad to see Mr. Hunt, from Melbourne; and he might inform him that, with 12 cwt. charges, there was a slight passage on the top of the retort. If they filled the retort full, he believed that it was necessary to have an ascension-pipe at each end; and he was altering some of the settings and putting an ascension-pipe at each end of the bench, so that they could fill the retorts solid.

Dr. DAVIDSON said that the actual cost of working of the Birmingham experimental plant was not so much as might have been anticipated, on account of the good results they obtained. If they reckoned the cost of gas into the holder, it was only a matter of 2d., at the most, more than in one of the large works—not the best works; and it only cost a few hundreds a year on the gas made. So that he thought the Birmingham Gas Committee were well advised in putting down even this large plant for the purpose of testing coal. Mr. Shoubridge had made some reference to the standard for valuing coal, and objected to his taking the standard of 12 to 14 candles with a No. 2 burner and 500 B.Th.U. net. He (the speaker) made no reference to a legal standard, but simply alluded to a standard of valuation; and 500 was a round figure. He had put the illuminating power low enough, so that it did not matter. They could hardly make gas of less illuminating power than 12 candles. Their own figures corroborated Mr. Shoubridge's. He was in agreement with the remarks made about a legal standard—that it ought to be a calorific one, and that the illuminating power should be quite subsidiary. But he did not think it should be discarded altogether, because with the progress which was being made, and with the gas produced in some of the new installations, it was necessary to have some sort of illuminating power standard; otherwise a consumer using a flat-flame burner might some day find that he got no light at all. With regard to filling the retorts, they certainly had the disadvantage referred to by Mr. Carpenter, that it was hand-work; and it was not easy to fill the retort so as to leave a uniform passage over the coal. They had employed charges of 12 and 13 cwt., with a duration of twelve hours; and he proposed to give one of the tests, even though it was not altogether satisfactory, and to point out that they got, as Mr. Bell had, a depreciation in the 12-cwt. charge of about 2½ per cent. on the illuminating power basis. But, very strange to say, they also found a depreciation in the calorific value, while Mr. Bell had an increase of 6½ per cent. As far as their experiments had gone, they did not find any advantage in the 12 and 13 cwt. charges; but the experiments were not altogether satisfactory, as had been pointed out. Still, he wished to say that they obtained the same result as Mr. Bell, approximately, on the illuminating power basis. He was in agreement with all that Mr. West had said about burners; but it was not sufficient to simply make gas without any reference to its quality. What they would have to consider in the future was the number of heat units obtainable per ton of coal. He was rather diffident in publishing figures with regard to Mr. Helps's anti-dip; and he quite appreciated his remarks. No doubt they got an unduly adverse figure, owing to the fact that they had no machine charging, and their retorts took about 8 minutes to discharge and charge. If they were charging with 6 cwt. of coal, it took about 3 minutes to charge; and with 12 cwt., about 8 minutes. He agreed with the remarks that had been made about the dry main and the retort-house governor, which the experiments certainly seemed to prove possessed a slight advantage. Mr. Valon spoke about the competition as between works and works, and the lowering of the multiple when it was necessary to alter the pressure in the retorts. This reduction

in the multiple was very seldom necessary to resort to; and when it was resorted to, it only affected the gas multiple, and by not more than 2 per cent. In the matter of valuation, he thought that if Mr. Valon would carefully read through the paper he would find that he (the speaker) had attempted to make an allowance for the increased yield per ton in carbonizing wages. It was certainly the case, as Mr. Randall had mentioned, that in all small gas-works close supervision was a profitable matter; and it was the great advantage in small works that they could keep every retort in good condition. He did not quite agree with Dr. Colman as to the difficulty in estimating accurately the weight of coke produced. They could do this with a high degree of accuracy by weighing the hot coke, except perhaps when they filled the retorts with 12-cwt. charges, when it was more difficult. With regard to the volume of gas given off and the percentage of hydrogen, it was a well-known fact that with vertical retorts at the end of the charge almost pure hydrogen was given off from the coke. Dr. Bueb had drawn his attention to this fact; and a recording calorimeter would show it when the retorts were burning off.

DE BROUWER STOKING MACHINERY AND COKE-HANDLING PLANT.

By S. Y. SHOUBRIDGE, of Lower Sydenham.

In the year 1899, the first De Brouwer coke-conveyors used in this country were installed at the South Suburban Gas-Works at Lower Sydenham. These serve a retort-house containing eighteen beds of eight retorts worked by West's compressed air machinery. There is a conveyor on either side of the bench running the full length of the house, both delivering the coke on to a transverse elevator conveyor which takes it to a series of overhead hoppers, whence it is discharged into railway trucks beneath.

These conveyors proved so satisfactory and economical that when, in 1902, another retort-house was remodelled and enlarged, it was decided to equip it with the same type of conveyor; and as by this time the De Brouwer-Jenkins stoking machinery had just been brought out, this also was adopted. The house, which is 324 feet long, contains twenty-six beds of ten retorts each; and the conveyor extends the whole length and for a distance of 63 feet outside, rising from the level of the charging floor at the end of the house to a height of 16 feet. The coke discharged at this point falls on to an inclined screen having rocking bars for removing the breeze and dust, and thence on to another horizontal conveyor 200 feet long, which distributes it on to the storage heap through numerous openings.

There is a pushing machine and a charging machine of the usual De Brouwer-Jenkins type, driven by electric power. This house has been at work almost continuously since it was started; and the cost of carbonizing, including everything from the unloading of the coal into the breakers to the delivery of the coke on to the heap, amounts to 8¼d. per ton.

In another retort-house, containing eighteen beds of seven retorts and six beds of ten retorts, the drawing and charging had, until the present year, been done by compressed air driven machines of the usual type; the coke being removed in tipping trucks drawn along rails to a raised gantry by means of a wire rope on either side of the bench, as shown on Drawing No. 1. This arrangement required men to quench the coke as it fell into the trucks, and others on the gantry to tip the trucks and discharge the coke on to the heap. As the coke had a fall of 10 feet from the lower retorts and 18 feet from the upper ones into the trucks, and another fall from the gantry to the storage heap, much of it was broken into breeze. The drawing and charging of the retorts involved the use of two drawing and two charging machines, with their attendants, and it was impossible, therefore, to work so economically in this house as in the other; the cost per ton being 18½d., against 8¼d. in the other.

It was decided, therefore, to instal the De Brouwer-Jenkins machinery, utilizing, as far as possible, the framework and engines of the existing machines, and to work it with compressed air supplied by the existing compressing plant. This has recently been accomplished. The coke trollies were discarded, and the gantry altered to suit the De Brouwer conveyors. A De Brouwer conveyor, 2 ft. 6 in. wide, is placed at the level of the charging floor, and, running the full length of the house, is carried beyond the end of it for a distance of 55 feet, rising at an angle of 30 degrees

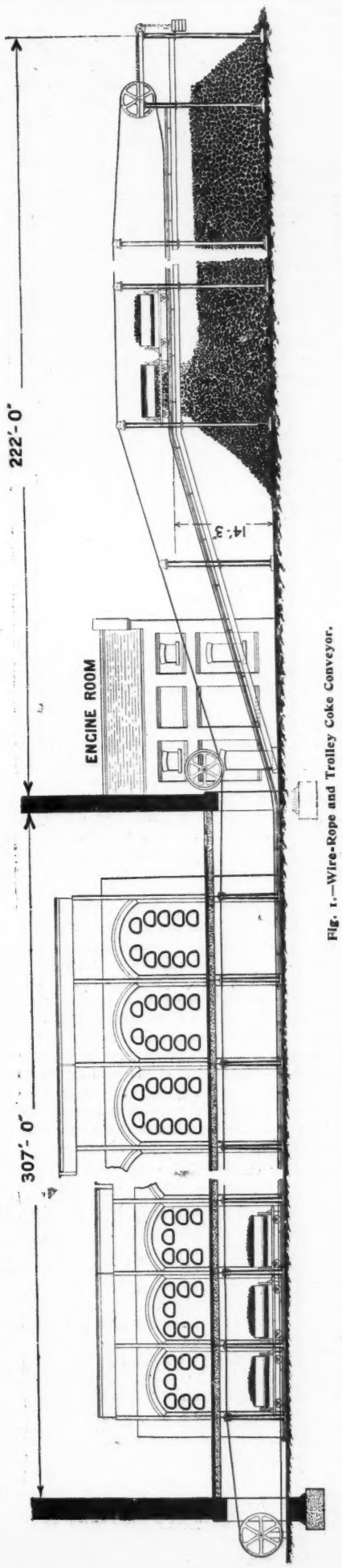


Fig. 1.—Wire-Rope and Trolley Coke Conveyor.

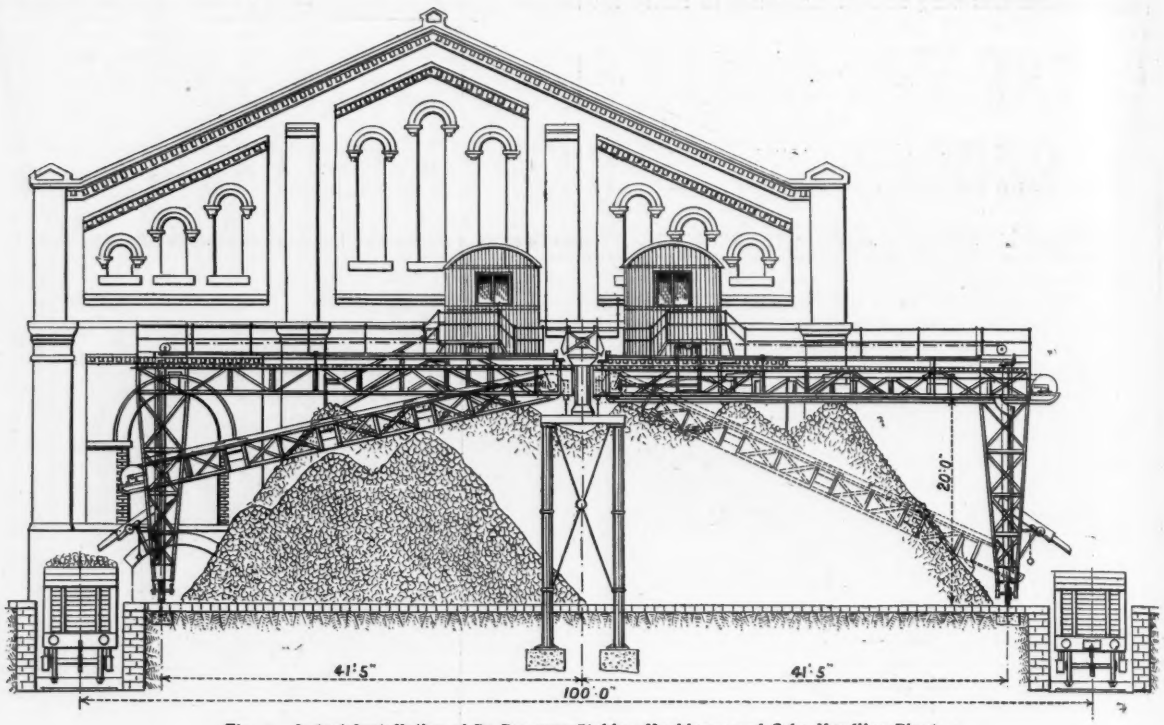


Fig. 2.—Latest Installation of De Brouwer Stoking Machinery and Coke-Handling Plant.

to a height of 27 feet, where it delivers the coke, over a screen with moving bars, into the trough of the yard conveyor. This is also of the De Brouwer type, and 205 feet in length.

On each side of the yard conveyor, a travelling and lowering conveyor is provided for stacking the coke in the yard without breaking it, and for loading it direct into railway trucks. These conveyors each consist of a trough and De Brouwer chain 2 ft. 6 in. wide by 40 feet long, carried in a steel gantry fitted with travelling wheels running on rails as shown in fig. 2. One end of the conveyor is suspended by chains, and the other is hinged so that it can be raised and lowered as shown, and thus avoid dropping the coke from any considerable height on to the heap. When loading the coke into railway waggons, the conveyor is brought into line with the waggon and raised so as to deliver the coke over a shoot fixed to the frame as shown and into the truck. The transverse conveyors are electrically driven by motors of 7½ H.P. working at 310 revolutions per minute, and have all necessary electrical equipment, including trolley poles of the "tramway" type. These collect the current from overhead bare copper conductors extending the full length of the yard conveyor.

The retort-house and yard conveyors are driven by the gas-engine used for the old conveyor, which is of 29 H.P.; and the electric current for the transverse conveyors is generated by a compound wound continuous current dynamo of 13 Kw. capacity, running at 750 revolutions per minute, driven by a 35 H.P. gas-engine.

Charging Machine.

The framework of the old machine, together with the operating platforms, travelling wheels and axles, travelling and hoisting gear remain much as before; but the old charger, hanging frame, and hopper were removed, and a new hopper with double rotary feeder and a De Brouwer projector have taken their place.

In the older type of De Brouwer charger, some difficulty has been experienced in getting fine coal, when wet, to leave the hopper regularly; and this causes delay in working, and irregularity in the thickness of the charge. To obviate this, the latest machine is fitted with two cast-iron drums having serrated faces at the bottom of the hopper. These drums are made to revolve at a suitable speed by means of a belt from the compressed air motor which drives the projector. An adjustable sliding baffle-plate is placed over and in front of the rollers, for regulating the flow of coal to the projector. The projector is of the usual type, and consists of an endless india-rubber band, 15 inches wide, carried round three pulleys and driven by the one nearest the front of the machine. The band also passes round a grooved pulley, 15 inches wide and about 3 ft. 3 in. diameter, a deep and wide groove in which is turned of such a size as to allow of the free passage of the coal from the hopper above.

The projector and feeder are driven by a compressed air motor with 4 in. diameter cylinders controlled by a spring governor, arranged to give a variable speed by means of a rotary hand lever with pointer and indicator face plate, of similar design to the rheostats on the electrically driven De Brouwer machines. The machine is constructed to charge five tiers of retorts; one portion of the house being already fitted with five-tier settings and the remainder ultimately will be. A telescopic shoot is provided to direct the coal on to the band when charging the four lower tiers of retorts.

Discharging Machine.

The frame of the other old charging machine, together with the travelling and hoisting gear, wheels, axles, and motor, have been used for this machine. The old hanging frame and charger were removed and replaced by a telescopic ram with hanging frame and driving gear of the Jenkins type. The telescopic ram is in two parts. The first or inner length consists of a strong steel rack having a hooded plate at the pushing end to hold the coke and prevent it from crushing up, and an articulated tail at the other. At the back end of the rack, slide blocks are fixed to slide inside the outer part or second length of the ram. These engage with suitable stops in the outer length, so that the first length, when at its extreme outward stroke, has a rigid bearing on the blocks inside the second length. The two lengths are thus connected, and the second length is in turn pushed out after the first. At the front end of the machine is a shaft carrying a sprocket wheel; and this is connected by suitable gearing with a compressed air motor, fitted with 4½-inch by 4-inch cylinders. The sprocket wheel engages with the teeth of the rack of the ram, and so pushes the ram forwards and backwards as required. The motor works at a pressure of 60 lbs. per square inch.

Coke-Conveyor.

This is made with cast-iron side plates bolted to a ⅜-inch wrought-iron bottom plate, jointed to make a perfectly watertight trough. The trough is fitted with cast-iron renewable bottom plates, kept in position by renewable cast-iron angle paths; the whole being held down by renewable runners made of 3½-in. by 3-in. by ½ in. steel angles, bolted to the side of the trough. The inclined portion of the conveyor outside the house is covered in with tongued and grooved match boarding, in order that the steam generated by the hot coke may assist in the quenching. The water for quenching is supplied through adjustable cast-iron sprays

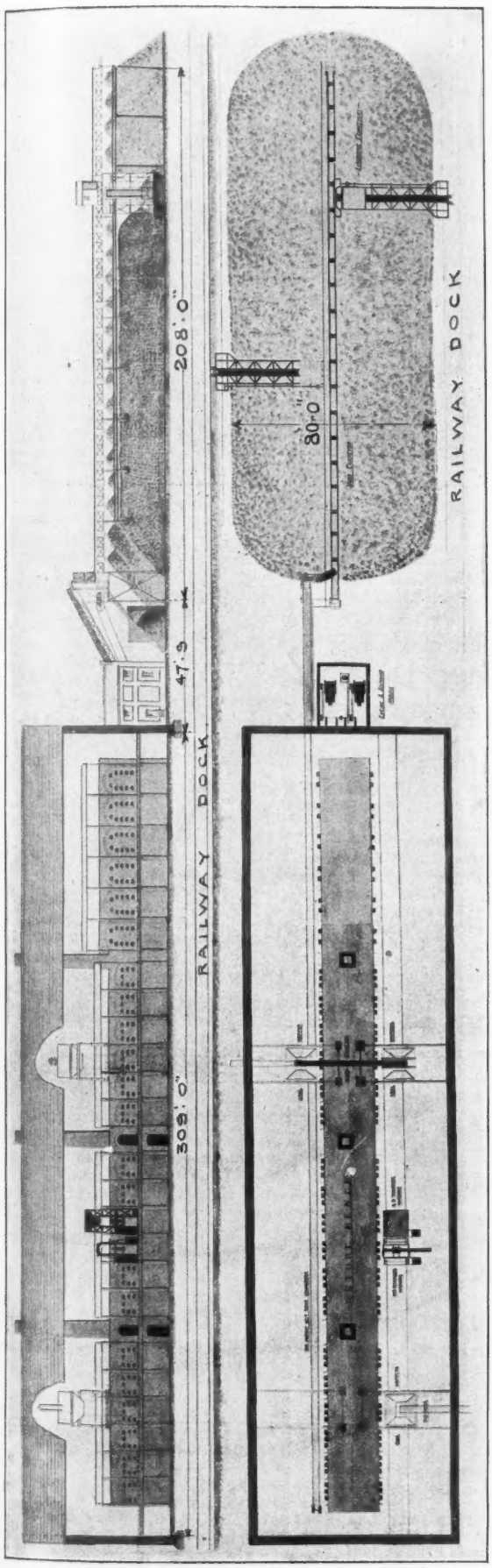


Fig. 3.—The Coke Handling Plant at the South Suburban Gas-Works.

fixed on the top of the trough. Underneath the trough, at the bottom of the inclined portion, a draining grid and water chamber, with adjustable overflow, are provided to remove any excess of water that might get into the conveyor. The chain is made of steel stampings.

Underneath the head of the inclined conveyor two screens are fitted so as to remove the dust and breeze from the coke before it passes on to the yard conveyor. The driving gear is so arranged that the conveyor may be worked by either of the two gas-engines if necessary.

The yard conveyor is fixed at a height of 25 feet above the yard level, and is substantially the same in construction as the retort-house conveyor.

The machinery in this installation has only just been completed; and it is therefore impossible to give any figures from actual work. From our experience in the other retort-houses, however, a very close estimate can be made, and there is no doubt the cost of carbonizing will not exceed 10¾d. per ton.

Under the old arrangement, the coke was loaded from the heap into the railway waggons by hand at a cost of 5½d. per ton; but this will now be done by the conveyor for less than 1d. per ton for labour—a saving which will give a very handsome return on the cost of the traversing conveyors. Our experience with De Brouwer conveyors shows that the life of a chain, in tons of coke moved, averages, for the retort-house conveyor, 58,600 tons, and the cost per ton per 100 feet traverse 0·59d., and for the yard conveyor 54,600 tons, at a cost of 0·54d. The life of the renewable bottom plates is about 3½ years, equal to 150,000 tons of coke carried. The protecting angles at the sides of the conveyors have proved very beneficial in reducing wear and tear of the chain.

The india-rubber belt of the charging-machine is the most vulnerable part of the machinery; and its life depends very largely upon the quality of the rubber used in its manufacture, and somewhat upon the character of the coal used. Large lumps of coal should not be employed with these belts. The average life of the belts has been 13,300 tons; and the cost per ton, ¼d.

	Per Ton of Coke Carried. (1)		(2)		Total.
Rope and trolley conveyor .	7·55d.	..	·95d.	..	8·50d.
De Brouwer conveyor . .	1·17d.	..	2·68d.	..	3·85d.

(1) Cost of labour in operating conveyors.
(2) Cost of labour and materials used in repairs.

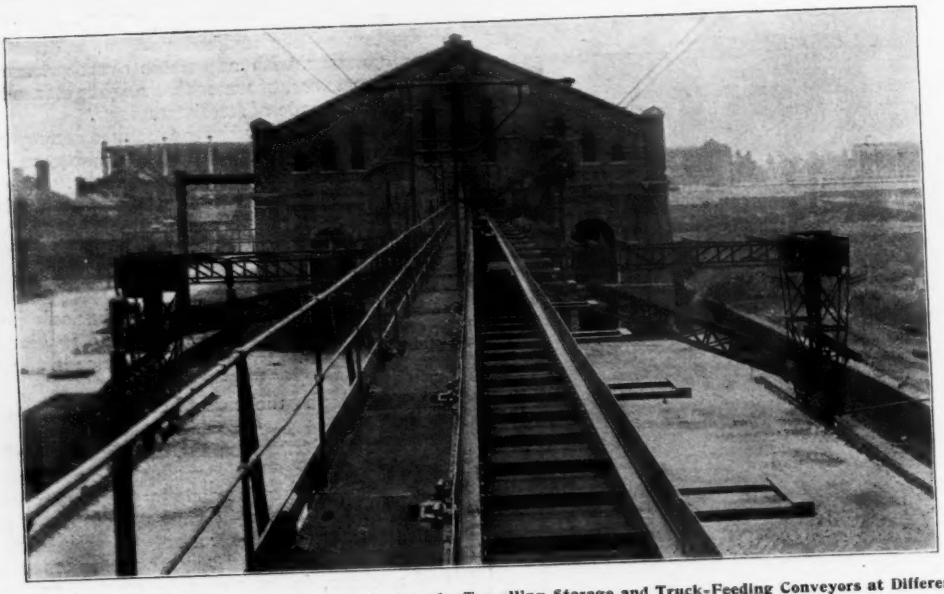
The rope and trolley arrangement is very economical to maintain; but it requires so many men in attendance while working as not only to nullify its advantage in this respect, but to make the total cost of working and repairs more than twice that of the De Brouwer conveyor.

As the arrangement of machinery described differs in several important respects from anything of the kind elsewhere, it is hoped that this description of it has not proved uninteresting.

Discussion.

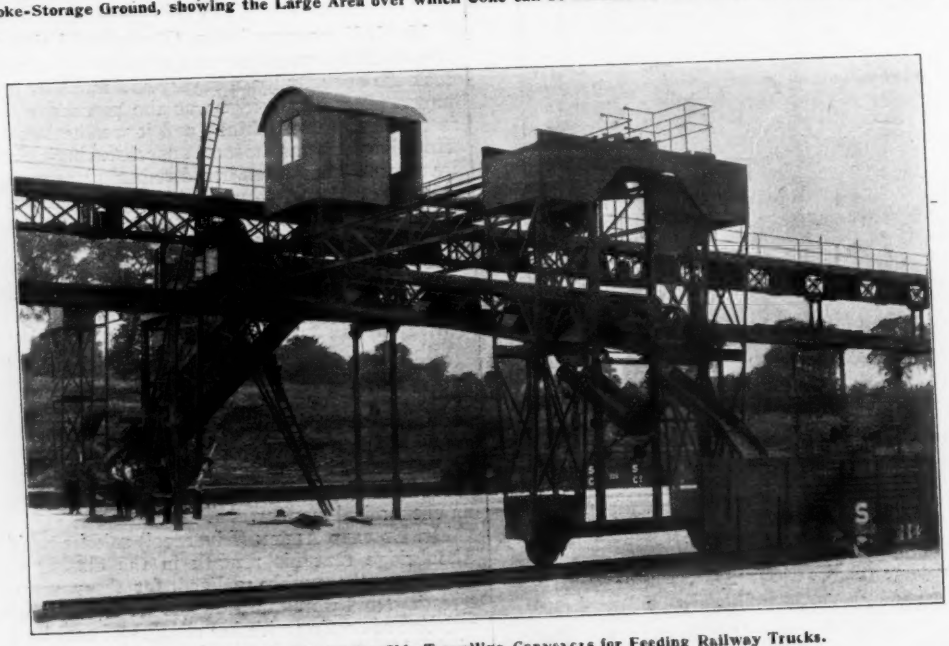
Mr. J. Ferguson Bell (Derby) said that he had used the De Brouwer conveyor a number of years, and therefore took the opportunity of saying how much he appreciated the paper. Mr. Shoubridge was the pioneer in this country in introducing the machine; and it was eminently successful. He believed it was the most successful hot-coke conveyor yet invented. They often heard remarks about the breakage of coke by conveyors; but, in his opinion, it was not the conveyor which broke the coke so much as the treatment it received afterwards by falling long distances. The arrangement Mr. Shoubridge had brought forward, enabling them to drop coke a short distance only, was a very admirable one. He said that the life of his chain was 58,600 tons; but he (Mr. Bell) had only been able to deal with about 45,000 tons. With regard to the width of the trough, in a new installation he was putting in he was increasing the width to 3 feet, and covering it over with a plate—something of the same kind as was done in Germany—to make it safer. If they used stoking machinery, it was absolutely necessary to have some efficient means for removing the coke; and Mr. Shoubridge had shown them how to deal with large quantities in an economical manner.

Mr. Edward Allen (Liverpool) said he could assure Mr. Shoubridge that his remark in the closing words of his paper was thoroughly realized, for the paper was very interesting, and would be valuable for future reference. The question of dealing with full charges of coal brought up that of the handling of the resultant coke; and for those who



A Perspective View along the New Yard Conveyor, showing the Travelling Storage and Truck-Feeding Conveyors at Different Angles.

The Coke-Storage Ground, showing the Large Area over which Coke can be Stacked by the Travelling Transverse Conveyors.



Illustrating the Use of the Side Travelling Conveyors for Feeding Railway Trucks.

were attempting to put in 10 cwt. to 11 cwt. charges, as they were in Liverpool, something better than the old style of the man with the barrow was required. It was interesting to notice the low cost of carbonizing which was obtained in this large installation; for 8¼d. was a figure which, some years ago, would have been a matter of great surprise. It was due undoubtedly to the magnificent installation which Mr. Shoubridge had to deal with. With machinery and large weights of coal, the cost came down nicely; and it appeared as if there was not much more improvement to be effected in respect to the costs, when they came down to 8¼d. Those having vertical installations, and those who were looking forward to them, were doing so in the expectation of the cost being brought very low; and no doubt this would be so. But after all, when it was reduced to 8¼d. there was not much margin left. He took it this included everything—from the coal in the breakers to the coke, after being screened, into stock.

Mr. SHOUBRIDGE: Yes.

Mr. ALLEN (continuing) said he had tried to find out what it cost to carbonize, apart from handling the coke; and he took as a figure 1·17d. per ton of coke, and multiplied this by 2, assuming 10 cwt. of coke would be the result from each ton of coal for sale. This, deducted from the 8¼d., left something like 6d. as the cost of dealing with the coal in the retort-house. It was only fair to say that he spoke of the stoking machinery he was familiar with; and with such an installation, he would have no hesitation in saying that the cost might be brought down to about 5d. He did not say that this could be done with one particular machine; but he was sure there were many stoking machines now on the market which would show, with a large installation, a very low figure of cost. With respect to maintenance, Mr. Shoubridge had not given them much detailed information as to the De Brouwer conveyor, except the points referring to the life of the belt, and so on. He did not know whether he could give a figure per ton of coal as representing the cost of maintenance; but, with respect to coke-conveyors, there were many who were looking out anxiously for an inexpensive means of conveying, screening, breaking, and delivering coke to their customers. While the figure was very low in working, the cost for maintenance they looked upon with some hesitation. Again, changing the figure from the ton of coke to the ton of coal, it gave them 2·34d. for operating, and 5·36d. for maintenance—the total being 7·7d. Having had some few years' experience with another form of coke-conveyor—the Temperley transporter—he had the cost carefully worked out as to maintenance per year, and found it ran to something under 1d. a ton, which included renewing certain coke-conveying skips which they had to use in connection with it. The cost of handling was a very low figure. All that was required in that case, in addition to the coke being wheeled out of the retort-house, was one man who operated the transporter; so it brought the cost down very low. It would, however, be hardly fair to say that this represented the cost of handling the coke, because the man in the retort-house must bring the coke from the mouthpiece to the quenching place, and then outside. With reference to the quenching of coke, it appeared to him that somebody should endeavour to provide better means of cooling coke. He was quite satisfied that the present method of putting water upon it was not a scientific one, and injured the coke considerably. He had had an opportunity lately of testing some coke which had been smothered (from the Riddings District Gas Company's Engineer), and found that it kindled easily, burned freely, and left very little in the grate but fine ash. It was very satisfactory. He had made some experiments with their own coke, trying in one case that which had been smothered, and in the other that which had been quenched; and the difference in the behaviour of the resultant cokes was very great. In the smothered coke, there was an absence of all cracking. It was simple to kindle; and it was a very free-burning coke; whereas coke quenched was cracking and spitting when it was put on the fire, and did not burn as freely. It appeared to him that there was an opening here for somebody, by means of closing the coke up in a perfectly air-tight vessel, or possibly putting it into a vessel and passing in carbonic acid or waste gases from the flues, or in some way taking the heat out of the coke without damaging it by quenching with water.

Mr. SHOUBRIDGE asked how it was smothered.

Mr. ALLEN said it was spread on the yard and covered with coke-dust. It was a long process, and took about 48 hours; so that the cost of handling the coke was excessive. He did not suggest that it was a successful practical method; but he did suggest that there was an opening for somebody to discover a cheap and efficient way of handling coke on this system.

Mr. D. IRVING (Bristol) wished to heartily congratulate Mr. Shoubridge on the very excellent carbonizing costs he had submitted in the particular retort-house he referred to, where the cost worked out at a total of 8¼d. a ton. But he should like to be perfectly clear as to what was included in this 8¼d. Did it include the foreman? Probably it did not.

Mr. SHOUBRIDGE: It included everything.

Mr. IRVING (continuing) said that he had his own figures, which he had taken out; and they did not include the foreman, because there was no particular foreman allocated to the special house, nor did it include the cost of exhausting, because the exhausters were worked for a number of retort-houses, and therefore it was very difficult to allocate the proper proportion due to one house. With these two exceptions, they had had in Bristol, in one of their works, a retort-house very similar to the one described by Mr. Shoubridge; and the cost there worked out in detail as follows: Unloading the coal, 0·9d. per ton; breaking, elevating, and conveying in overhead hoppers, 0·62d.; actual cost of carbonizing (*i.e.*, of discharging and charging the retorts, including attendance, cleaning mouthpieces, and sweepers), 5·17d.; working the furnaces (and there were 24 settings of nines), 1·45d.; labour costs of their conveyors (and they had a complete set of coke-conveyors), 0·64d.; labour, attending to the engines for driving the entire installation, also 0·64d.—making a total of 9·4d. per ton of coal carbonized, from the time the truck of coal was received at the railway siding until the coke was screened and stacked in the yard. With regard to coke-conveyors, he thought they were helpful and necessary for the economical working of a large carbonizing plant, but the coke-conveyor was not to be estimated simply by the life of the chain, upon which point the author placed considerable importance. In addition to this, there certainly was the cost of power, and there was the cost of maintenance of the structure, and the trough, and the appliances for the working of the conveyor. With regard to the life of the chain, they had at Bristol a number of years' experience in the working of De Brouwer and similar conveyors; and he was glad to say they had secured an even better life than Mr. Shoubridge mentioned. At one of their works, where they had 1500 feet of De Brouwer conveyor working, the best result they had attained was 71,000 tons for the life of one particular chain, which was excellent—especially having regard to the length of the conveyor, about 180 feet of actual work. The most important thing with regard to this class of conveyor was, not only the length of it, but the angle and the height at which it was intended to convey the coke into the yard. At their Stapleton works, where they had had working for over four years a conveyor of practically the De Brouwer type, but made a little heavier, working twelve settings of nines, and where the lift at the angle at the end was only about 3 feet, in order to deliver it on to the conveyor, they had a life of 95,000 tons of coke, which he considered fairly good. Apart from the question of the life of the conveyor, he had taken out the actual cost of repairs and renewals upon the works for seven years, during the time they had employed conveyors and mechanical appliances, and compared it with the seven years previous; and he was pleased to say that the total cost of repairs and renewals was considerably less during the later period. It was very difficult to give exact figures; but it might be accepted as fairly conclusive that, when they took the entire cost of the work, with no arranging or manipulating of the figures, the latter seven years showed a considerably less cost for repairs and renewals than when the work was done by hand. It might safely be taken that the cost of maintaining the plant was not excessive. But apart from the cost, a well-designed coke-conveyor was essential to economical working with modern methods of carbonizing. The results would have been very much better, were they not in this particular house hampered by the size of the retorts. As had been mentioned, it was essential to have good-sized retorts; but here they had the old-fashioned stereotyped size of 20 in. by 15 in. If, instead, the retorts had been 24 in. by 16 in., the costs would have been greatly reduced, both for carbonizing and otherwise. Unfortunately, with these conveyors there was a great amount of friction. In other words, the chain conveyor was not economical for the power expended. In their Avon Street works, there were over 1500 feet of conveyor working; and, to drive this

plant, when light, required 25 H.P., and when loaded it only needed 28 H.P. So that the real efficiency of this class of plant was just a little over 10 per cent.

Mr. A. C. Hovey said he would confine his remarks more particularly to the coke-conveying machinery. He had had the honour of laying some particulars before one of the local Associations on two occasions with regard to a coke-conveyor such as had been put before them that morning. The length of the conveyor had since been increased, and the figures which were published at the time—namely, in 1903 and 1904—he had no doubt had now been considerably improved upon, not only because of the increased length of the conveyor reducing the working costs by giving it more work to do, but because, during the intervening time, the design of the chain had been much improved. There was no doubt a great deal of friction on chain conveyors, but they were a considerable improvement in this respect over the ordinary plate-carrying conveyor, which he thought was obsolete so far as coke conveying was concerned. What required considering more than any other point was the formation of breeze. He had had experience of places where the price of coke was so high that if they made 2 per cent. of breeze above what would be produced by ordinary hand labour, or some other method, they would do away entirely with the value of the machinery adopted. What they wanted to consider was that coke was a fragile material, and must be dealt with in a very gentle manner. The upward curve of the conveyor was undoubtedly the place where a great deal of this breeze was formed. If they could have a horizontal conveyor, and deliver the coke gently into some other receptacle by which it was conveyed and deposited in the position required, it would be a considerable improvement on the upward curve. Mr. Shoubridge had not given any particulars with regard to the percentage of breeze he made. If there was even a slight drop of 2 feet when the coke came on a moving mechanical arrangement such as a chain, they got the coke falling over itself, and so being ground up to a certain extent. During this evolution of design, it seemed to him they were gradually coming to the telpher system, by which the coke was received almost without a drop at the mouth of the retort, and gradually carried and deposited in the position where it was required. In Mr. Shoubridge's installation, it appeared to him that the storage was extremely small. It might be suitable at a works where they could dispose of the coke immediately it was made; but in cases where they had to store the equivalent of three to four months' make (as was necessary in some instances), it would require a coke conveyor of much greater length. He believed there were some gentlemen present who could make some remarks on the telpher system, which he considered would be more generally adopted in gas-works in future.

Mr. Allen said they had the telpher system at one of their works; but it had not been long enough in operation to afford any definite figures in regard to maintenance. It was, however, working admirably. The coke was not disturbed from the time it left the retort until it was put into the hoppers or screens as the case might be.

Mr. E. A. Harman (Huddersfield) thought this was one of the most valuable papers ever presented, because it was a record of actual experience; and this was the information they desired to obtain. There were many points he should like to speak on about conveyors; but it seemed that the discussion ought to be confined to this installation on the De Brouwer system, and was not concerned with any other machinery. He would not, therefore, now attempt to make comparisons, but would suggest that contributions which members might like to make on the subject should be submitted to the Council for inclusion in the "Proceedings." When figures were given in a hurried manner they were not capable of being carefully considered. One wanted to know the actual wages paid. The difference between the wages in the North and the South was considerable, and to simply quote a rate per ton did not allow of any real comparison. A gentleman recently told him that he paid his stokers 3½d. per hour. They were thankful in Huddersfield to get them at 8d.; and in London they probably had higher wages than that to pay, considering the machinery they used.

The President said he had had some considerable experience with different forms of conveyors, and a good deal with the De Brouwer; and those who went to Croydon the next day would have an opportunity of seeing a plant which was not a telpher, but which aimed at carrying out something on the same system. The coke was dropped on to a conveyor running along in front of the retorts; then into skips holding about 1 ton each, and afterwards taken up by means, not of a telpher, but of an electric crane running on the top of a gantry, and then put straight into the hoppers. From the hoppers, it dropped out at the bottom on to a "Marcus" conveyor, which, without shaking it as the ordinary conveyor did, carried it straight to the waggons, where it was loaded for sending away. Though he was sorry to say the whole of the plant was not in operation—the retorts not being in use—he would be able to show the general working of it, and also the "Marcus" conveyor, carrying coke and screening it on the way to the trucks.

Mr. Shoubridge, in reply, said he did not attempt to make his paper a very elaborate one. In fact, it was simply a stop-gap, which he had prepared in consequence of another member at the last moment unfortunately not being able to give the one he had promised. He thanked Mr. Bell for his remarks. It was quite right to say that he was the first to introduce the De Brouwer into this country; and he was glad to state that he was as great a believer in it as ever. He also agreed that the breakage of coke was not due to the conveyor. He should think there was less breeze formed in this way than in almost any other, because the coke did not move after it fell on to the trough of the conveyor, but remained perfectly still, and was carried along without rolling upon itself at all. There were arrangements in some conveyors by which the coke fell from one conveyor to another, in changing the direction; and it was in these falls that the breeze was principally made. He noticed that Mr. Bell was introducing a somewhat wider conveyor; and possibly he would find this an improvement. But he (the speaker) acted on the advice of Mr. Jenkins, who had had the greatest experience in this matter; and they could see that if they could get the coke along a 2 ft. 6 in. conveyor, the dead-weight of the chain must be less than with a wider one. They had a 2 ft. 6 in. conveyor at work at present; and though the pusher pushed out the coke very rapidly, and in great bulk, so that some of it sometimes fell on the floor, still there was no great difficulty in trimming it back into the conveyor. He quite agreed that with the full charges now used, and the pushing out of the coke especially, the conveyor was an absolute necessity. No means of hand conveyance was at all possible with the large charges which were pushed out with such great rapidity. A continuous conveyor was wanted; and this was why he thought the telpher was not quite the best form of dealing with such charges of coke. There would be a difficulty in getting the buckets one behind the other. A very large number would be required; otherwise the work would be delayed. He was quite familiar with the installation Mr. Allen had put in at Liverpool, and an admirable one it was; but he was not sure whether it was applied to a large number of retorts worked by stoking machinery. If not, there would be ample time to get the telpher buckets backwards and forwards. But, with machinery working in a very large retort-house, it was practically continuous all day. In their own big retort-house, there was no cessation throughout the twenty-four hours. There was a relief set of men; and it was kept working the whole time. In fact, there was a continuous stream of coke to be dealt with; and he could not quite see how this could be managed with the telpher arrangement. Mr. Allen also called attention to the quenching of coke; and he agreed with him entirely that a better system was desirable. But from experiments he had made with coke smothered-out with breeze, he was quite satisfied that this system was absolutely impossible. One could imagine what would happen in putting an immense quantity of breeze on to a stream of hot coke, in order to quench it. He was astonished that the idea ever entered anyone's head. There might be some mode of quenching coke they did not yet know of; and this was one of the problems Dr. Davidson might very well tackle with his test-plant. He was glad to hear from Mr. Irving that his figures could confirm those he had given with regard to the cost of carbonizing, and that Mr. Irving had obtained even a longer life with his conveyor chain than he had. As that gentleman had pointed out, the life of the chain was largely affected by the angle at which the coke was taken up. The wear and tear increased very much where this angle was increased. He agreed with him that the cost of repairs, when worked out, would be considerably less than of working by hand. He also agreed that coke-conveyors were absolutely essential for modern methods of working. This must be obvious to everyone who had had

experience. It was true the friction of the chain was considerable, and formed a good part of the working cost; but this form of chain was almost the lightest in existence. All other forms had additions which, of course, added to dead-weight and wear and tear. Some form of chain was absolutely necessary for dealing with large quantities of coke continuously. He was glad to hear that the results obtained since Mr. Hovey read his last paper, in 1904, had been improved. They were very good then; but he was not at all surprised that better had been achieved, because, in the matter of coke conveying, as years went on the chains and other parts were improved and simplified. They had not reached finality by any means; and no doubt they would get cheaper and cheaper. He could not agree with him that 2 per cent. of breeze above the amount obtained by hand labour did away with the advantage of the coke-conveyor.

Mr. HOVEY pointed out that it was a special instance he referred to on the Continent, where coke was at the time selling at 40s. per ton.

Mr. SHOUBRIDGE said that in this country 2 per cent. of breeze was not a great matter; while the advantages of so handling huge quantities of coke were undeniable. It was true he had not given any quantities of breeze, because he had not had time to go fully into the details, and did not want to draw comparisons with other forms of conveyor, but simply to show what they themselves had done. With regard to the storage space, considering the size of the retort-house, it was not very large; but they did not reckon to store the coke long. They mostly sold it as fast as it was made.

REPORT OF
REFRACTORY MATERIALS COMMITTEE.

The Committee, consisting of Messrs. James W. Helps (President), E. Allen, John Bond, A. E. Broadberry, H. G. Colman, W. Doig Gibb, Thomas Glover, Thomas Goulden, D. H. Helps, W. R. Herring, Edward Jones, James Paterson, S. Y. Shoubridge, Alex. Wilson, Harold W. Woodall, and F. J. Bywater (Hon. Secretary), present the following report on the work done during the year.

It was thought essential, before giving any consideration to the question of the quality of retort and firebrick material generally, to have authoritative information with regard to the results obtained from material now available, the temperatures at which various parts of retort and water-gas plants are worked, &c.; and for this purpose enquiry-forms were sent out to a number of representative gas-works in Great Britain and Ireland. At the same time the opportunity was taken to enquire the views of engineers of those works, as to the desirability of preparing standard specifications for the manufacture and testing of the various kinds of refractory material employed on gas-works; the possibility of standardizing some of the patterns of retorts; the institution of an independent testing laboratory; and other questions bearing on the subject.

It was recommended that the various temperatures should be taken by the same pyrometer, so that the information might be as comparable as possible.

A very satisfactory number of replies were received; both small and large undertakings being included in the returns.

The information sent in has been summarized, and is given below.

Number of undertakings sending returns.	31
Number of works	48
Total make of coal gas represented. . .	270 million per diem.
Total make of water gas represented . .	49 ,, ,,

Coal Gas.

Number of beds of retorts represented .	2059
(of these 1748 are horizontals, 310 are inclines, 1 vertical).	
Pyrometers used—Féry, 35; others, 8; not mentioned, 5.	
Kind of retorts used—Moulded, 33 works; segmental, 12 works; not given, 3 works.	
Life of retorts—Without patching, average 797 days.	
With patching, ,, 1257 ,,	
Life of combustion chambers—Average 1321 ,,	
Temperatures—Retorts.	Average maximum 1909° F.
,,	minimum 1558° F.*
Combustion chambers	,, maximum 2397° F.
,,	minimum 2212° F.
Producers	,, maximum 1966° F.
,,	minimum 1766° F.
Regenerators . . .	,, maximum 1622° F.
,,	minimum 1220° F.

* The minimum temperature on the bottom of retorts is much less than this immediately after charging, and a special investigation of the subject has been made by means of an electric recording pyrometer, for the purpose of obtaining the greatest variation of temperatures which the material has to withstand. Records as low as 809° F. have been obtained at this point.

Water Gas.

Number of sets represented—63.	
Temperatures—Generator . . .	Average maximum 1811° Fahr.
,,	minimum 1489°
Carburettor . . .	,, maximum 1381°
,,	minimum 1014°
Superheater . . .	,, maximum 1291°
,,	minimum 1142°
Average life of generator lining (without repairs)—187 days. Repairs usually required consist of replacing the lining about 4 feet up from the bars.	
Total life of generator—This varies in the returns from 1½ to 17 years. When the repairs above mentioned have been executed, the life of generator linings in the majority of cases appears to be about 8 to 10 years.	
Life of carburettor (without repairs)—	
Lining.	Very few repairs required. Returns vary from 4 to 13 years. Many original linings still untouched.
Chequer work.	Considerable repairs appear to be required to a portion of the material. Some plants require repair half yearly, others yearly—the latter being in the majority.
Total life of carburettor—	
Lining.	See note above.
Chequer work.	Varies considerably. Average of returns about 700 days.
Life of superheater (without repairs)—	
Lining.	Very little repairs required. Original lining still remaining in many plants.
Chequer work.	Average 415 days.
Total life of superheater—	
Lining	See note above.
Chequer work.	Varies very considerably according to the extent of the repairs executed annually.

List of Questions Appended to the Enquiry, and Replies Thereto.

1.—*Remarks and criticisms on material now available.*

3 are satisfied.
5 fairly satisfied.
15 dissatisfied, or say room for improvement.
2 dissatisfied, but say that gas committees and companies are partly to blame for making cheapness the first consideration.
9 give no answer.

2.—*Sizes of ordinary bricks employed.*

Almost without exception the ordinary bricks used are 9″ × 4½″ × 3″, or 9″ × 4½″ × 2½″.

3.—*Size of retorts.*

23 installations of horizontals 22″ × 16″.
12 ,, ,, ,, 21″ × 15″.
6 ,, ,, inclines $\frac{24''}{21''}$ × 16″.
19 ,, ,, irregular sizes.

4.—*Adoption of a standard pattern for retorts.*

24 object, or would only adopt in case of new work.
6 have no objection.
2 doubtful.
2 do not answer question.

5.—*Preparation of standard specification.*

26 in favour.
2 doubt practicability.
2 against.
4 do not answer question.

6.—*Method of testing refractory material.*

7 perform no tests.
17 put bricks into combustion chambers or settings
3 have testing furnaces.
3 make practical tests of all new material.
4 do not answer question.

7.—*Foundation of independent testing laboratory.*

16 favourable without reservation.
6 favourable with some reservation. Generally as to locality, expense of maintenance, &c.
2 doubtful.
5 against.
5 do not answer question.

The opinions expressed in replying to the above questions will very materially assist the Committee in arriving at a decision on the various points raised; and several engineers make valuable suggestions when replying to Question 1.

The subject of standardizing ordinary bricks has been sometimes raised; but it would appear that no interference with present custom is called for.

The standardization of retorts has also been recommended at intervals ever since retorts have been used, but has always been complicated and rendered almost impossible by engineers having their own ideas on the matter of the most suitable cross sections to be employed.

The replies to Queries 3 and 4 indicate the difficulties of the question.

A close examination of the cross sections of the large number of 22-inch by 16-inch retorts now used, however, reveals the fact that there are not serious differences between many of the patterns; and this is being looked into further, with a view to attempting, if possible, standardization in this size of retort.

The replies to Questions 5 and 7, relating to the preparation of standard specifications, and to the foundation of an independent testing laboratory, indicate that these will be welcomed if some obvious difficulties can be overcome. There will, of course, have to be several specifications according to the requirements of the material.

It will thus be seen that we have a very comprehensive statement of the opinions of engineers on this subject, and of the temperatures at which retort and water-gas plants are worked, and the "life" obtained from material employed.

It is considered that this will be of great assistance to manufacturers, whom it will guide in the selection of their clays for making material to be used in various parts of plant, and will enable them to reserve their best clay for those which have to withstand the highest temperatures and severest working conditions.

The statements of temperature cannot, of course, be considered final or exact for all conditions, but a suitable allowance above the average figures given can be made, and will provide a safe maximum temperature to be resisted.

After the conclusion of the enquiry, it was decided to hold a conference with the makers of refractory material, for the purpose of discussing the best ways and means of carrying into effect the objects which the Committee have in view. It was thought that the readiest method of reaching the manufacturers as a body would be to invite the Retort and Fire-Brick Section of the Society of British Gas Industries to assist the Committee in this matter. Unfortunately, the Chairman of the Section, Mr. W. P. Gibbons was abroad at the time; but in his absence the Secretary of the Society was asked to act for him, and arrange for the election of a deputation—stress being laid on the desirability of its being representative, not merely of the Retort and Fire-Brick Section of the Society, but of the whole body of manufacturers. The following is a list of the gentlemen who attended, and the firms they represent:—

Mr. A. Cliff . . .	Messrs.	Williamson, Cliff, Ltd.
Mr. W. Barrett .	„	Leeds Fireclay Company.
Mr. A. H. Pearson	„	Harris and Pearson, Ltd.
Mr. J. Morton .	„	Joseph Morton, Ltd.
Mr. G. H. Perry .	„	Mobberley and Perry, Ltd.
Mr. C. W. Thomas	„	E. J. and J. Pearson, Ltd.
Mr. G. H. Timmis	„	Timmis and Co.

And Mr. A. L. Griffiths, Secretary of the Society of British Gas Industries.

The deputation were informed of the work which the Committee had already carried out, and the results of the enquiry; and the whole subject of the supply of refractory material was thoroughly discussed. The manufacturers expressed their satisfaction at having placed at their disposal the useful information in regard to the temperatures which the material they supplied had to withstand, and signified readiness to do everything they could to make the quality of their material equal to the required standards.

Ultimately, it was unanimously decided that the first thing to do was to draw up standard specifications for the manufacture and testing of the various kinds of refractory material; and a Joint Sub-Committee was elected for this purpose. It was also arranged that they should have the advice of a professional clay expert to assist them in this work.

The Committee informed the deputation that it was their wish for the specification to be at first as simple as possible, and that it should be amplified from time to time as necessity proved was desirable.

As indicated in the annual general report of the Institution, these specifications will probably be ready before next season's requirements of retorts and fire-bricks have to be ordered; and it is hoped engineers will avail themselves of them when making their contracts for this material.

Discussion.

Mr. J. W. Morrison (Sheffield) congratulated the Committee, and especially Mr. Bywater, on the work they had done, and was quite in favour of the suggestion that a Committee, consisting of manufacturers and themselves, should be formed to draw up a specification. It would considerably strengthen the hands of engineers connected with corporation departments if the specification which was drawn up was such as would probably eliminate the manufacturer who gave them any sort of material he liked. They knew that when tenders were received, it was as a rule left to the engineer to make the best he could of the material purchased for him, which was very often the cheapest. He was not at all sure that analysis alone would show the right material to select, because he remembered making some analyses of a German material, which he should have put on one side as quite unsatisfactory, but it was brought to his notice by a large steel manufacturer of Sheffield as being exceptionally good, very durable, and capable of standing a large amount of wear and tear. Analysis would not give all they wanted—especially from the silica point of view.

Mr. W. P. Gibbons (Dudley) said he came, as Chairman of the Fire-Brick Section of the Society of British Gas Industries, on purpose to thank them for the kindly way in which they had been approached, and also to congratulate the Committee on their excellent report. There was more information in it for fire-brick makers than they had been able themselves to obtain after years of investigation. He could assure them, on behalf of the fire-brick makers, that they would gladly do all they could to meet the wishes of the Committee.

Mr. C. W. Thomas (Stourbridge) desired to associate himself with the remarks of Mr. Gibbons. Personally, he thought the report would be most helpful to all manufacturers, for hitherto the information they had been able to obtain was rather scanty. Engineers did not care to give information themselves; but this report would enable manufacturers to deal with any problems that came before them from a much better standpoint.

Mr. Samuel Glover (St. Helens) said when he first received the report he was much surprised to find that the Committee had had to deal with replies from only 31 undertakings; but they had certainly made good use of the information they obtained. He thought they must have done it under a feeling of disappointment that, after all the trouble they had taken to formulate these questions, only 31 out of the large number of undertakings represented by the Institution had replied to the inquiries. If, however, their hearts failed them on this account, he thought they might well take courage from the consideration that from such a small number of replies they had been able to elicit so much valuable information. If they had only given the information as to the maximum and minimum temperature of retorts, combustion chambers, producers, and regenerators, they would have done very good work for the industry. This work was emphasized, and made much more valuable to gas engineers in the construction and use of retorts and refractory material generally, by the note appended to the table of temperatures. The qualities required were shown much more by the amount of variation, than by the extreme temperature which the retort at its best had to stand. His attention had been called to this subject by the experience of the coke-oven people, who explained that to get the best material for standing the attrition of pushing out a charge from coke-ovens, and also the heat and the great change of temperature, they had to go to Belgium for the bricks to line the ovens. He felt that this was a great reflection on British manufacturers of refractory material; but he believed their dignity was going to be recovered, if it was ever lost—or retained, if it had not been—by this investigation. It suggested to the users of horizontal or any other sort of retorts, the extraordinary strain they were putting on the retort by lowering the temperature so enormously every time it was charged—the amount of expansion and contraction which must be brought about by these changes—had never been realized in the carbonizing of coals so fully as it could be now. If the temperature was much less at the bottom of the retorts immediately after charging, it must be substantially less throughout a considerable period of the burning-off of the charge. It had hardly been realized that the coal was carbonized at a very much less temperature than that which they found when it was drawn. The point the Committee were now striving after, with reference to standardizing, was being gradually

brought about, and they could not hope to expedite it much. They would all be glad if the Committee persevered in bringing out a standard specification, and they would best show their gratitude by having patience with them when they wanted to change the wording of it—especially if it tended to its improvement. He was rather surprised that the Committee did not take the opportunity of emphasizing the use the Leeds University might be in doing the work which it was asked should be done in regard to the foundation of an independent testing laboratory. Surely, if the Leeds University was to be of any use at all, the Committee might have pointed to the fact that there they had a place where any such work could be done.

The PRESIDENT said he did not know why Mr. Glover assumed that they had not the Leeds University in their minds in making this suggestion. He found nothing at all to warrant him in coming to this conclusion.

Mr. F. J. BYWATER (Birmingham), in reply, said there was a great question among engineers and others studying this matter as to whether the test in a laboratory was of any use at all; and that was the reason for asking engineers what their ideas about it were; and whether there should be a laboratory at all. Having got some idea what their opinion was, they intended to act upon it. The locality of the laboratory was open at present; but, in his opinion, there could not be a better place than Leeds. Some other suggestions had, however, been made—for instance, that the National Physical Testing Laboratory might be approached—but, generally speaking, Leeds University was most favoured. He should like to say that the number of works which sent replies by no means represented the whole industry. They could not send out the inquiry forms to all works; but a list was drawn up of such as were considered to fairly represent the industry generally, including large and small concerns. Over 50 per cent. of those sent to replied.

JOINT CONFERENCE OF COMMERCIAL SECTIONS OF THE UNITED KINGDOM.

On the afternoon of last Tuesday (which was, of course, the opening day of the annual meeting of the Institution of Gas Engineers), there was held at the Institution of Mechanical Engineers, Storey's Gate, S.W., a Joint Conference of the Commercial Sections of the United Kingdom, which was on the same lines as the gathering that took place, it will be remembered, at the same time last year. The meeting, to which all members of the Institution were invited, was well attended.

Mr. S. MEUNIER (Stockport), who occupied the chair during the formal part of the proceedings, said he was very pleased to tell those present that Mr. J. W. Helps (Croydon), the President of the Institution of Gas Engineers, would preside over the gathering when the preliminary business had been completed.

The HON. SECRETARY (Mr. H. Kendrick, of Stretford) then read the minutes of the previous meeting, the resolutions passed at delegates' meetings, and some correspondence.

On the proposition of Mr. CHARLES WOOD (Bradford), seconded by Mr. J. H. TROUGHTON (Newmarket), a hearty vote of thanks was accorded to the Institution of Mechanical Engineers for the use of the hall, and to Mr. W. T. Dunn, the Secretary of the Institution of Gas Engineers, for arranging the meeting.

Mr. HELPS then said it gave him great pleasure to accede to the request of Mr. Meunier and Mr. Kendrick to take the chair, though he could scarcely understand why he was asked to do so, as Mr. Meunier, he was sure, was doing the work very well. Perhaps, however, the reason was that it would allow more liberty to Mr. Meunier himself to take part in the discussion. At any rate, he (Mr. Helps) certainly did not intend to interfere in the discussion, but meant simply to act in a judicial capacity.

The HON. SECRETARY then read the following

REPORT OF THE JOINT COMMERCIAL SECTIONS.

To the Members of the Institution of Gas Engineers.

GENTLEMEN,—The necessity for combination and organization in the commercial work of the gas industry was fully discussed at the quarterly meeting of the Manchester District Institution of Gas Engineers in September, 1902, when the establishment of Commercial Sections was strongly advocated by Mr. S. Meunier (Stockport) and others. The importance and value of an interchange of opinions and experiences in relation to the many matters directly affecting the commercial work of a gas undertaking was emphasized, particularly the production and disposal of residuals and the prevention of dumping, under which circumstances the railway companies' traffic receipts are benefited at the expense of the gas undertakings.

The fixing of prices could never be a part of the work; the sole object being the discussion, tabulation, and publication of information *re* market conditions and prospects, a thorough knowledge of which will enable all engineers and managers to avoid isolated and often precipitate action. The knowledge gained by the interchange of opinions among a small group of managers during the previous few years had strengthened their convictions that such a scheme would be of great value to the industry.

The scheme was approved, and sections were formed in Lancashire and Yorkshire; the first meetings being held in January, 1903. Since then other sections have been formed in the Eastern Counties, Scotland, and the Southern District; another is in process of formation in the North of England; and similar institutions have been working for some time past in Cornwall and the South-Western Counties.

The need for union, collaboration, and co-ordination of the work led to the joint meeting of all sections in London on June 15, 1909; and it is felt that a greater influence can be brought to bear upon the industry if this union is made permanent, and the approval and influence of the Institution of Gas Engineers is extended to the work.

The main features of the work carried out and discussed at the Commercial Section meetings are: Tabulation of coke stocks and prices (local and national); development of local sales; disposal of surplus coke; advice on markets open; coal market prospects; residuals market prospects; and labour questions and rates. These questions are more or less debated at every general meeting. Stocks and ruling prices are reported upon and market conditions discussed; and the opportunity of thus keeping in touch with the latest information is a decided advantage in directing the policy of the various undertakings represented, and must have a steadying effect generally.

Among the many topics brought before the sections are the following, which indicate the variety of subjects considered:—

- Telegraph Acts, 1863, &c.
- Charges for reinstating roadways.
- Stand-by supplies.
- Advertising.
- Card systems.
- Standard conditions for coal tenders.
- Workmen's compensation.
- Effect of Miners' Eight Hours Act.
- Rating of gas-works.
- Maintenance of incandescent burners.
- Standard regulations for gas-fitters.
- Income-tax allowances.
- Responsibility for leakages.
- Repayment of Local Government Board loans.
- Railway Companies' Charges.

The demand for the standard regulations for gas-fitters drafted by the Lancashire Section proves the need of such a compilation; and the interest evinced in the negotiations by the same Section and the Lancashire Gas Coal Association for the settlement of the standard conditions for coal tenders and contracts shows the necessity of such conditions. These latter have been considered by the joint sections, and are hereby submitted for approval to the members of the Institution.

Many questions—most of them important—are also introduced impromptu; the variety of experiences expressed being of immense value to all the members.

The results accruing from the discussions, the undoubted success of the commercial movement, the keen interest displayed by individual members, and the establishment of sections throughout the country, all prove the necessity for commercial organization, and fully justify the action of the Manchester and District Institution in 1902. With the enthusiasm and loyalty of all which is absolutely necessary for the well-being of the sections, the future should see them united; and with the recognition and support of the Institution of Gas Engineers, and with the organization perfected, the sections should be in a still stronger position for effective work, to the benefit not only of the gas engineer and his particular undertaking, but the industry as a whole.

On behalf of the Committee,
S. MEUNIER, *Convener.*
H. KENDRICK, *Hon. Sec.*

Gas-Works, Stretford, May 7, 1910.

Mr. R. G. SHADBOLT (Grantham), in moving the adoption of the report, said it needed no remarks from him. It carried its own recommendation.

Mr. S. O. STEPHENSON (Tipton) seconded the motion; and it was unanimously carried.

The conference then proceeded with the *agenda;* but the discussion on the next item proved so long, that at its conclusion,

Mr. SHADBOLT moved that the remainder of the business be adjourned until the next joint meeting.

Mr. WOOD seconded this; and it was agreed to.

On the recent occasion of the installation of the Duke of Devonshire as Chancellor of the University of Leeds, in succession to the late Marquis of Ripon, Professor Smithells, the Dean of the Faculty of Science, presented Lord Rayleigh for the degree of Doctor of Science. He referred to his Lordship as one who, "joining to noble birth the highest rank in the aristocracy of science," stood in a line of men of whom England is justly proud. Lord Rayleigh is Chief Gas Examiner for the Metropolis.

ELECTRICITY SUPPLY MEMORANDA.

Excusing Themselves to the Public—Living in the Past—How it is Worked—Charges—Electric Motors and Gas Compressors.

The Westminster lighting contract refuses to leave us, through the continued irritation in electrical circles. Electricians have talked vigorously over it, and around it, privately and in the electrical press. The contract has been minutely dissected, with the view of finding out weak points; and it has all ended in the exposure of a terrible mass of electrical ignorance. The talk has been transferred from the electrical technical papers to the public press. Such a defeat of electricity must be excused, by hook or by crook, in the public eyes. Something has been said on the matter in "The Times;" and the "Pall Mall Gazette" has published the representations of the Secretary and General Manager of one of the Electricity Supply Companies. This gentleman makes as foolish a mess of the explanation as the electricians and the electrical journalists have done who have preceded him. As a matter of fact, he says nothing—except one ludicrous thing—that has not been said before. It seems to be a serious grievance against the Gaslight and Coke Company that they have mains in every street, whereas the Electricity Companies have not. Whether the idea is that the Gas Company ought not in tendering to have taken advantage of their condition in this respect, we cannot say; but there is the grievance right enough in black and white. Then it is said that the Gas Company have undertaken to supply gas at an absurdly low rate. They have not undertaken to supply gas at all. What they and the Electricity Companies were asked to tender for was illumination. But as to the absurdly low price the Company are believed to be charging for the gas to be consumed, the estimates of electricians have ranged from 5d. up to (in the "Pall Mall Gazette" article) 10½d. per 1000 cubic feet; whereas in the same article the net cost of production is stated to "appear" to be 1s. 10d. per 1000 cubic feet. This is carefully non-committal; and a good thing, too, because it is foolish if the figure is supposed to represent the net cost in the holder. Last year (according to the recognized authority, "Field's Analysis") the net cost per 1000 cubic feet of the Company's gas in the holders, less residuals, and including coal, salaries, wages, purifying, and wear and tear, amounted to 11·88d.; and no less than 3·87d. of this is charged for wear and tear. However, the Company are, in this respect, doing something that is little short of heinous in the eyes of this Electrical Secretary and General Manager. It would be most interesting to know if his Company are one of those with consumers connected to their cables who are taking current at 1d. or a fraction of 1d. per unit, while others are paying perhaps 4d., 5d., or even 6d.

Then there is a very comical statement, over which we are not going to spend time puzzling ourselves—this being Institution week. Speaking of the 3000-candle power lamps, the critic says: "Reckoning the average of ten hours per night, at the rate of 300 feet consumption *per hour*, the loss to the Company will be about 2s. 6d. per lamp." Dear critic, regarding this consumption, these are not big raging gas-furnaces, but inverted gas-burners; and the gas-lamps are not intended for heating London streets, but for illuminating them. It is curious, but it is true, these electrical critics have suddenly dropped into a greater knowledge of high-pressure incandescent gas lighting than gas companies themselves possess. This one points out that there is the very difficult problem of keeping a high standard of light with the fragile mantles. The inverted mantles are quite different things from the upright form in regard to their durability. But why do the electricians worry over these matters? It is the Gas Company who have to face the penal clauses—not the Electricity Companies. The same fount of gas knowledge informed the "Pall Mall Gazette" that he did not think it possible to obtain 3000 or 4000 candle power with gas. References in opposition: Aldwych, and *ante*, p. 691. But there are the poor shareholders of the Gaslight and Coke Company. Over them, the electricians are sympathetically lachrymose. How grateful the shareholders ought to feel. The strange thing is there has not been a slump in the Company's shares through the agitation of shareholders frightened over the Company securing this Westminster lighting business. But, there, the greatest absurdity is the display of affectation on the part of electricians. Keeping the matter alive, by indulging in so much assumption, shows how severe the blow has been, and how hard it is to forget it.

The "Electrical Review" has published an article headed "Street Lighting: Electricity *v.* Gas." There is nothing new about it. But there is in it a reversion to the long-since published intelligence as to the action of the Corporation of Berlin in having resolved to convert the street lighting arrangements, by a fixed annual expenditure, to high-pressure and low-pressure inverted gas-lamps. A large part of this work has already been done. The matter was referred to in the report of the City of London deputation nearly twelve months since; and the "Electrical Review" has just bestirred itself into making inquiry into the matter. But it seems that our contemporary has confined inquiry to electrical engineers, and has not been sufficiently inquisitive to go to quarters from which definite information could have been obtained. The electrical engineers, however, concur in saying that "they have no knowledge of any such intention on the part of the City Council; but they would not be surprised to hear of it at any time, because the gas-works belong to the City and the electric works to a Company." The same old tale. Now let us give the "Review" a few facts as to the truth of which they may inquire of their electrical engineering friends who would not be surprised, &c., or of more reliable sources of information. The Municipal Council of Berlin are gas suppliers; but they take no credit for the gas used for public lighting, and so seriously diminish the profit on the undertaking. The Imperial Continental Gas Association, however—a large private concern (with a capital of several millions) of which peradventure the "Review" has heard—also light a very considerable portion of Berlin proper, and nearly all the western suburbs. Furthermore, the Municipality draw an extraordinarily large revenue from the electric light undertaking; and so the more current that is used, the better for them. This rather alters the position as presented by the "Review."

Then this mirror of electrical opinion says the Corporation of the City of London ought not to have much difficulty in dealing with any such recommendation as that alleged, for they themselves possess ample testimony, from actual experience, of the great advantage of electricity for street lighting over high-pressure gas-lamps. This is why, we suppose, electric arc lamps are about to be uprooted in New Bridge Street, and high-pressure gas-lamps take their place. Our friends of the "Review" are fond of antiquity. There comes to mind some testimonials as to the superiority of electric lighting published in its columns, the writers of certain of which by the time of publication had passed to the land where neither rust nor moth corrupts, and where electric bills and collapses cease to trouble. The experience of the great advantage, &c., which the "Review" refers to, is a test of three or four years ago between flame arc lamps and high-pressure (vertical burner) gas-lamps. Our contemporary, without any reference to the dictates of its conscience, says the illuminating power of the three flame arcs used in the tests was 3951-candle power (it is necessary to be particular to 1 when dealing with candle power in four figures), as against 1220-candle power by the five gas-burners. Because our contemporary lives so much in the past, it has not heard of single high-pressure inverted gas-burners that will give 1500-candle power on much less consumption of gas than was required by the old type of, and only half as efficient (if that), high-pressure vertical burner. Our contemporary does not know that high-pressure lighting has been greatly advancing in efficiency; and, in its ignorance, it finds it amusing to read the statements of gas companies as to the relative cost of incandescent gas and electric lighting. Let our electrical contemporary go on finding similar amusement, for its laughter under such circumstances amuses others. There is much else in our contemporary's article; but it is of the common order of electrical argument. There is an omission. We do not see any notice in the article as to Westminster, Bethnal Green, and Hackney having bowed to the inverted gas-burner, and resolved to make no conversions to electricity for at least five years.

Electrical news is informative as to the scraping together by electricity-supply departments of all the little pieces of municipal lighting or power business that they can lay hands on. This is interesting; and it is easily worked. Nothing is left undone to enable the municipalities to carry out their sacred duty of making the electricity undertaking pay at the expense of the ratepayers. One thing that is done is to so arrange Committees that the interests of the electricity undertaking are well looked after. We seem to trace cause and effect in one or two happenings in connection with Hastings; and illustration of one of the serious disadvantages under which gas companies are placed who have to compete with municipally-controlled electricity concerns. A report was recently made to the Hastings Town Council regarding the comparative cost of gas and electricity for lighting and power at the Corporation Queen's Road Depôt. The average for four years' gas, of course, came out higher than for electricity. But there is a careful guarding from the public of knowledge as to the price per unit charged at the depôt; and there is no statement as to the time and work conditions under which the rival commodities were used. We should not be surprised to learn that some old gas-engine that sadly needed repair or replacement was formerly used for power, and that old flat-flame burners were partly, if not wholly, employed there (especially in the winter time by the men for warmth), without any consideration for economy. Notwithstanding, the difference in cost is only a few pounds; but in this comparison, the Committee take no account of the £208 (or thereabouts) that it was estimated would have to be, and so no doubt was, spent on the electricity installation, repayment and interest on which on the ordinary lines would represent a financial engagement running over some twenty years. It is, too, a beautiful example of the effrontery of the Roads Committee publishing a comparison like this without details, when the Electricity Committee have had £2000 from the rates for the same year to cover trading losses. Perhaps a bit of this was lost at the depôt. But this paragraph may end on the point with which it started. It is interesting to note that Mr. Councillor Coussens, the Chairman of the Roads Committee, is also a member of the Electricity Committee; and therefore to that extent he is partly responsible for running the electricity undertaking at a loss. Alderman Tree, who in the Council expressed his delight with the saving shown at the depôt, is the Vice-Chairman of the Electricity Committee. There are, we believe, altogether seven or eight members who sit on both the Roads Committee and the Electricity Committee. Recently the Electricity Committee have been increased by the addition of four members; so that now, with a little engineering, the Electricity Committee can have a majority on most of the

Corporation Committees. How can a private competitor hope to work in obtaining municipal business against such a condition of things as this, or how can the interests of the ratepayers be safeguarded?

There are one or two interesting points regarding charges for electricity before us. In various quarters lately, there has been much discontent regarding the repressing power, in the matter of trading freedom, of the old public lighting clause in Gas Acts, which gives the local authority the right to have gas for public lighting at the lowest price charged to any consumers in the district of supply. This clause had birth when gas was used only for lighting purposes; but the local authorities in most cases now, notwithstanding the changed conditions, refuse to recognize that the clause refers to the lowest price under the circumstances existing at the time it was framed, and insist on its literal interpretation under the modern conditions of gas use and trading. The unfairness of this is obvious. Electricity suppliers are not subject to this restriction; and certainly, in common fairness, the regulations affecting the supply of gas and electricity ought to be on uniform lines to give equal freedom in competition. The matter in a somewhat similar form has cropped up at Watford, where, at a Local Government Board inquiry, it has been asked that no firm or firms, or private consumers, should be supplied at a cheaper rate than that paid for public lighting. Of course, the electricians can trot out no end of musty stock answers to this request, though there is no doubt that, if the suggested regulation were applied, and the average public lighting charge were adopted as the minimum price for any private purpose, there would be less cause for complaint as to the ridiculously low charges made for power and heating in some places. Designedly we use the word "average," as several cases have come under notice where, though the street lighting load comes on top of the private lighting load, the price for current for street lamps, in order to get to a cost something comparable with gas, has been cut down to an extraordinarily fine figure per unit—so fine that we should not be surprised to see it disappear altogether, and some excellent and receptive alderman get up in the local council and assure his fellow-members that the electrical engineer tells him, and he is convinced, that the transaction is a healthy thing for the electricity station.

As to the second point, in regard to prices. In certain places—Sunderland comes to mind—there have been little tussles regarding the price of energy for driving motors used with gas-compressing plants for high-pressure gas lighting. Of such plants, electricity departments are highly jealous; and apparently, judging from their attitude, find them dangerous competitors. This finds expression in a resolution passed by the Electricity Committee of the Woolwich Borough Council that, for the guidance of consumers, the term "power" shall include all purposes to which electrical energy may be applied other than for use either directly or indirectly for lighting. The price of supply to consumers who use motors for driving gas-compressing plants is now to be at the rate of 4d. per unit. Electricians are mightily inconsistent nowadays in respect of those principles that of old they used to "love, honour, and obey" in ordering their prices for different purposes. A motor for a gas-compressing plant is required practically every working-day of the year; but an electric radiator is required only in the winter time, when more current is needed for lighting. The electric heater is favoured. The public lighting load comes on top of the private lighting load. That, too, is favoured as against the motor for the gas-compressing plant. A motor is employed for driving a knife-cleaning machine. That is favoured against the motor for driving a gas-compressing plant. The motor that drives a gas-compressing plant demeans itself. It is a pariah, and must be treated accordingly. What idiocy! By making this distinction, electricity suppliers not only bring ridicule upon themselves, but help to advertise the economy of high-pressure gas lighting. Some of them would, if they could, refuse to supply these motors altogether. Sunderland tried this on; but the law was not with the Electricity Department, and happily this was realized before going to further senseless lengths.

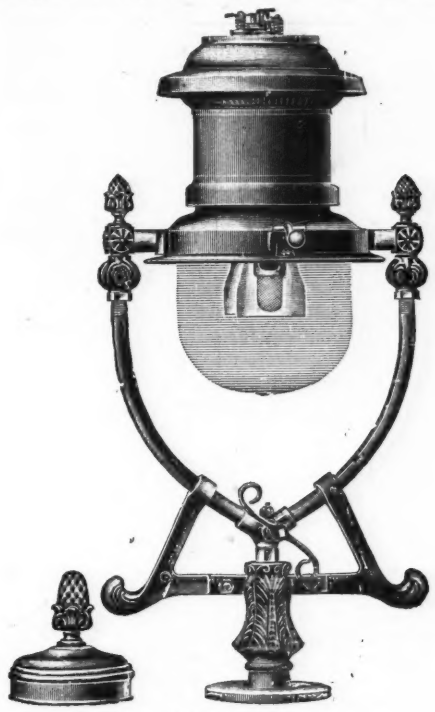
The Livesey Professorship at Leeds University.

At the monthly meeting of the Council of the Leeds University last Wednesday, the draft Deed of Gift by which the Livesey Memorial Fund is transferred to the University (*ante*, p. 487) was approved. An Advisory Committee was appointed to manage the department under the control of the Council, and the following resolution was passed: "The Council record their deep sense of the honour done to the University by the offer of the fund raised as a memorial to the late Sir George Livesey for the endowment of a professorship of applied chemistry relating to Coal Gas and Fuel Industries. The Council gratefully accept the offer, and hereby establish a Livesey Professorship of Coal Gas and Fuel Industries, subject to the conditions prescribed in the Deed of Gift submitted on behalf of the Livesey Memorial Fund."

Among the honorary degrees conferred by the University of Cambridge on the occasion of the announcement of the results of the Mathematical Tripos last Tuesday was that of Doctor of Science upon Sir Oliver J. Lodge, Principal of the University of Birmingham, and Mr. W. H. Perkin, Professor of Organic Chemistry in the Victoria University, Manchester, and son of the discoverer of the aniline dyes.

GRAETZIN STREET-LAMP IMPROVEMENTS.

THERE is now to be seen in the show-rooms of Messrs. J. & W. B. Smith, of Farringdon Road, a type of Graetzin street-lamp which embodies one or two improvements that should add further to the popularity of this particular make of high-power gas-lamp. As shown in the illustration, air and gas adjustment are secured from the outside; all the regulating parts being at the top of the lamp, and simply covered by a removable cap. The addition to the lamp, however, to which our attention was principally directed was in connection with the arrangements for lighting. This is accomplished from the outside; and there is no need to have a bye-pass burning during the whole of the twenty-four hours. When lighting-up time arrives, all that it is necessary to do is to give the lever a quarter-turn, in which position it acts upon a spring



A Graetzin Street-Lamp.

fitted just above it, and this allows what is practically the bye-pass supply of gas to flow—the main-cock being bored for this purpose. The bye-pass gas, taking, for example, a two-burner lamp (though, of course, the device could be equally well arranged for any other number), then passes into a three-way spray. One outlet of this is in direct line with a small channel communicating with the outside of the lamp; and there in a very short space of time sufficient gas collects in this aperture for the attendant to light it with a torch, when the flame flies back to the other two jets of the three-way spray. When the lever is given another quarter-turn the spring already referred to is released, and the bye-pass supply consequently cut off—the full flow of gas passing to the burners. Thus the bye-pass is shut out of action both when the ordinary gas supply is full on and when the lever is turned right to the "off" side. This should prove a useful adjunct to the lamp—from the point of view of convenience, as well as that of cost of gas and maintenance.

Reduction in Price by the Commercial Gas Company.—The Directors of the Commercial Gas Company announce a reduction from 2s. 6d. to 2s. 4d. per 1000 cubic feet in the price of gas, commencing from the taking of the Midsummer quarter indices. In a notification to the prepayment consumers, it is stated that the penny-in-the-slot meters are adjusted to give 25 cubic feet of gas for each penny; being at the rate of 3s. 4d. per 1000 cubic feet. The collector will calculate the amount required to pay for the gas consumed at the rate of 3s. 2d. per 1000 cubic feet, and return to the consumer the difference.

British Rainfall Statistics.—The British Rainfall Organization, which was founded by the late Mr. G. J. Symons in 1860, has been placed upon a permanent footing by the gift of the unique collection of rainfall records, and the leasehold of the historic rainfall house in Camden Square, to a Board of Trustees, who are all rainfall observers, consisting of Dr. H. R. Mill (Chairman), Sir John Murray, Sir Alexander Binnie, Mr. Francis Druce (Treasurer), Mr. R. M. Barrington, Mr. C. L. Brook, Mr. C. J. P. Cave, Mr. D. W. Freshfield, Mr. H. Mellish, and Mr. J. G. Wood. An endowment fund is being formed by the Trustees, and several observers who intended to leave legacies have expressed their intention of contributing the amounts to this fund. The institution has always been self-supporting.

PUBLIC LIGHTING—COMPETITION AND CHARGE.

A RETROSPECT AND A FORECAST.

[COMMUNICATED.]

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(*Concluded from p.* 695.)

IT is interesting here to note that it was in 1852 that the first officer was appointed to test the gas for illuminating purposes—viz., Dr. Letheby. In 1860 the police first rendered assistance by reporting the defects in the public lamps, owing to the "loud complaints," while in 1864, for the first time, it was suggested that a "Clerk of the Works" be specially appointed for the "inspection of the public lighting, and to give his whole time to that duty." Thus the period of "districting" and "competition" and the beginning of "amalgamation" has been dealt with, when the charge for public lighting by meter was in vogue. The following table shows the prices charged for public lighting for 54 years.

During 1865, a Special Committee in the City of London sat dealing with complaints as to defective street lighting and the inferior illuminating power of the gas, and considered as to the propriety of—(1) Seeking statutory powers to take upon itself the manufacture, supply, and sale of gas; (2) as to purchasing the mains of the gas companies and establishing a manufactory for

TABLE *Showing Prices Charged per* 1000 *Cubic Feet of Gas for Private Consumption, and the Prices Paid for Lighting the Public Lamps from* 1807 *to* 1864 *Inclusive.*

Year.	Name of Company Contracting for the Public Lamps								
	City of London Gas Company.		Chartered Gas Company.		Great Central Gas Company.		Number of Hours Burning, 4300.
	Price per 1000 Cubic Feet Supplied by Meter to Inhabitants.	Batswing Burners. Estimated Consumption 5 Cubic Feet per Hour. Price per Lamp per Annum, including Lighting, Extinguishing, and Repairing.	Price per 1000 Cubic Feet Supplied by Meter to Inhabitants.	Batswing Burners. Estimated Consumption 5 Cubic Feet per Hour. Price per Lamp per Annum, including Lighting, Extinguishing, and Repairing.	Price per 1000 Cubic Feet Supplied by Meter to Inhabitants.	Batswing Burners. Estimated Consumption 5 Cubic Feet per Hour. Price per Lamp per Annum, including Lighting, Extinguishing, and Repairing.	
	s. d. s. d.	£ s. d.	s. d. s. d.	£ s. d.	s. d. s. d.	£ s. d.	
1807 to 1822							Rental per burner per hour.
1823	15 0	5 5 0	15 0	5 5 0			
1824	15 0	5 5 0	15 0	5 5 0			
1825	15 0	5 5 0	15 0	5 5 0			
1826	15 0	5 5 0	15 0	5 5 0			
1827	15 0	4 14 6	15 0	4 14 6			
1828	13 6	4 14 6	13 6	4 14 6			
1829	13 6	4 14 6	13 6	4 14 6			
1830	13 6	4 14 6	13 6	4 14 6			
1831	12 6	4 14 6	12 6	4 14 6			
1832	12 6	4 10 0	12 6	4 10 0			
1833	10 0	4 10 0	11 3	4 10 0			
1834	10 0	4 10 0	10 0	4 10 0			
1835	10 0	4 10 0	10 0	4 10 0			
1836	10 0 & 9 0	4 10 0	10 0 & 9 0	4 10 0			
1837	9 0	4 10 0	9 0	4 10 0			
1838	9 0	4 10 0	9 0	4 10 0			
1839	9 0	4 10 0	9 0	4 10 0			
1840	9 0	4 10 0	9 0	4 10 0			
1841	9 0	4 10 0	9 0	4 10 0			
1842	9 0	4 10 0	9 0	4 10 0			
1843	8 0	4 10 0	8 0	4 10 0			
1844	8 0 & 7 0	4 10 0	8 0 & 7 0	4 4 0			
1845	7 0	4 4 0	7 0	4 4 0			
1846	7 0	4 4 0	7 0	4 4 0			
1847	7 0 & 6 0	4 4 0	7 0 & 6 0	4 4 0			
1848	6 0	4 4 0	6 0	4 4 0			Reduced at Lady Day to 6s. per 1000. Reduced at Midsummer to 5s., and at Christmas to 4s.
*a*1849	5 0 / 4 0	4 4 0	5 0 / 4 0	4 4 0			
1850	4 0	4 4 0	4 0	4 4 0			
1851	4 0		4 0		4 0	3 17 6	Contract taken by the Great Central Gas Company.
1852	4 0		4 0	3 12 0	4 0	3 17 6	
1853	4 0		4 0	2 19 6	4 0	3 3 0	Contracts let for three years.
1854	4 0		4 0	2 19 6	4 0	3 3 0	
1855	4 0		4 0	2 19 6	4 0	3 3 0	
1856	4 0		4 0	4 2 0	4 0	4 4 0	Contracts let for three years.
1857	4 0		4 0	4 2 0	4 0	4 4 0	
1858	4 0		4 0	4 2 0	4 0	4 4 0	
1859	4 0		4 0	4 8 0	4 0	4 10 0	Contracts let for three years.
1860	4 0		4 0	4 8 0	4 0	4 10 0	
1861	4 0 & 4 6*		4 0 & 4 6*	4 8 0	4 0 & 4 6*	4 10 0	The Contract with the Great Central Gas Co. was for 3 ft. burners. The Chartered Co. 5 ft. burners.
1862	4 6		4 6	4 14 6		3 0 0	
1863	4 6		4 6	5 9 6	4 6	3 10 0	
1864	4 6			5 9 6	4 6	3 12 6	

a Commencement of competition. * Raised at Michaelmas to 4s. 6d.

the supply of gas, or laying down their own mains, and obtaining the supply of gas in bulk by public tender. At this time matters became so serious that it was decided to consult Mr. T. G. Barlow, "an engineer of considerable eminence," and to have the opinion of Mr. Hawksley, "probably the first gas engineer in England," to assist Dr. Letheby.

With regard to the charge for public lighting, the Directors of the Chartered Gas Company, in 1865, stated that until recent years "the charges had been framed on an erroneous principle, that the former price was unremunerative to them, and that, recently, the companies had come to the conclusion that there was no reason why the price to the local authority should be less than to other consumers, and that the prices had been, accordingly, calculated upon the amount of gas consumed and the other expenses incurred in the lighting, and this mode they thought to be fair, and one from which they could not depart." It was then finally decided to make an offer to the companies for authority to undertake the lighting, cleaning, &c., of the street lamps (affixing a meter to every twenty lamps or thereabouts, so as to ensure an average consumption), and that further assistance be obtained, if possible from the Police, in the supervision of the public lighting. It having been decided to fix the meters, the companies shortly after broke away from the attitude they took up, that a meter should be fixed to every post; and eventually it was agreed to pay upon the "average meter system"—viz., one meter to about every 36 lamps, the mean of the readings to be the charge.

PRICE PER GOVERNOR BURNER PER HOUR.

In 1865, reports of defective street lighting being continuous,

it was stated that "the deficiency cannot have escaped the observations of any one, and all the investigations of the last few years show that there has not only been a deficiency in the quantity of gas supplied, but a general neglect in most of those conditions necessary to be observed to ensure efficient public lighting;" and it was suggested that the placing of governors or regulators, "so as to ensure, in some degree, that the proper quantity of gas is afforded to the lamps," should be required of the companies.

As the system of gas lighting became extended, and the new flat-flame burner became more reliable, together with the introduction of governors or regulators that could be placed on the line of service immediately before the burners, so as to ensure that neither more nor less gas per hour than that contracted for should pass into the burners, and also to satisfy the officers under the local authorities charged with the oversight of lighting, the "average-meter system" began to fall into disuse; and with a settled number of hours for lighting per annum—viz., 4300 in the central or busy parishes, and 3940 and 3773·5 for the outlying districts who take advantage of the twilight and dawn, especially during May, June, and July, and in country districts where the moon was taken into consideration, and instructions were given that the lamps were to be lighted one hour before the moon set and extinguished one hour before it rose—a scale of 2300 hours was agreed upon. The settled hours per annum—viz., 4300, 3940, 3773·5, and 2300—enabled the companies to contract per lamp per annum with governor burners. At the present time, the writer only knows of one Metropolitan local authority (Shoreditch) who still retain the meter system.

In 1883, on the amalgamation of the London Company with the Gaslight and Coke Company, it was ordained by an Order in Council dated May 22, that the charge for gas for public lamps to the local authorities north of the Thames should not exceed the price charged by the Company in the area of the London Company south of the Thames—viz., that of the South Metropolitan Company's charge. This has caused a saving of many hundreds of thousands of pounds to the northern authorities, as the South Metropolitan Company's price is, at this date, 6d. per 1000 cubic feet less, and it has been 11d. per 1000 lower than the Gaslight and Coke Company.

Charge per Burner per Recorded Pressure.

In May, 1908, the City of Calcutta decided "that all public streets should in future be lighted by gas;" and at the end of last year the Municipality invited tenders for the public lighting of their city and introduced a system of charge that is as novel as it is new—viz., price per lamp per annum according to a recorded pressure. Details having been settled and the contract with the Oriental Gas Company signed, it remained to constitute a Lighting Department to carry out the details of the new arrangement. The birth of the present proposal originated from the same cause that has been detailed in the early part of this article.

The scheme which had been brought forward by the Special Gas Committee of the Corporation was the outcome of the thought and suggestions of Mr. Alfred Mansfield, who has been the adviser to the Corporation. In coming to this decision, the Chairman of the Calcutta Corporation (the Hon. A. Earle) said that while he had no inordinate belief in the capabilities of local bodies to undertake work of a commercial character, the experience of what the Oriental Gas Company had done for them, and the situation presented in connection with the public lighting, admitted of exceptional treatment.

Councillor Braunfeld, speaking at the meeting of the Corporation at the time the report was adopted, said that the experiment they were about to make might prove a success or a failure, and after all the past experience of experiments, he was not so sanguine as the Chairman and others with regard to its success; while Councillor Mitter said he was against the local administration of gas lighting, as they would not be able to fix the responsibility of anyone in particular for defective lighting.

The general outline of the scheme is as follows:—

(*a.*)—A general survey of the public lights should be made which should be diagonally spaced.

(*b.*)—Where the positions of the lights have not been selected with due regard to efficiency and economy, they should be altered.

(*c.*)—Lamp provided with consecutive numbers.

(*d.*)—The preparation of a plan on a large scale showing the positions and number of all lights, the illuminating value of the lamps to be indicated by several circles—*i.e.*, a 40-candle power light by one circle, a 60-candle power light by two circles, &c.

(*e.*)—A general survey of the pressures at all points should then be taken during the hours of lighting, when the private consumption is heaviest, to ascertain the minimum pressure to be expected at any lamp. The pressures to be marked on the plan in different colours, the plan would then show at a glance any unevenness of pressure. If the plan is not found to be satisfactory, owing to the great unevenness of pressure, steps are to be taken to insist on the Company using every endeavour to distribute the pressure evenly. It being reasonable to expect that the pressure would not be higher than 3 inches, the contract provides that no pressure must be less than *z* inches.

(*f.*)—The pressures to be taken to the nearest tenth of an inch; a separate colour being used on the plan for each tenth of an inch between 2 and 3 inches. These pressures to be accepted as pressures it is possible to maintain for an extended period, and at which tests of the consumption of nipples will be made.

(*g.*)—Having settled the plan of pressure, the next step is to ensure that these pressures are maintained. For this purpose, positions must be selected for fixing recording pressure-gauges. Each recording gauge is to be an index of the pressure of a certain number of lamps. For instance, if a pressure recorder indicates a pressure of 2½ inches, it will show that every lamp would be getting, within a certain area, not less than 2 inches. The nipples being tested and gas paid for at these pressures, care must be taken that the penalties are enacted for any fall of pressure on the recorder below 2½ inches; a table of penalties to be prepared in connection with each pressure holder.

In addition, a laboratory is to be set up with a laboratory assistant, to make tests and see that the conditions of the contract are faithfully carried out, and the records tabulated. He is to be a superior, well-paid man, be familiar with instruments of precision, and have had experience in laboratory work. He should be able to understand and appreciate the difficulties of distributing gas over an extended area, and rigidly enforce the penalties clauses when desirable. It was also suggested that the Chief Engineer of the Municipality, who had been associated with Mr. Mansfield in the preparation of the contract, should be the officer responsible for the carrying out of the contract; being, in Mr. Mansfield's opinion, eminently capable of undertaking the work, having an excellent knowledge of the subject, and skilful in the laboratory—debiting the new Lighting Department with a portion of this official's salary.

It was decided to appoint a "Superintendent of Lighting" at a salary of £400 or £600 per annum, according to ability, who should have full charge and be capable of advising the Corporation as to the Department, selection of burners, &c.; be experienced in photometric work; able to take charge of a thoroughly up-to-date and well-equipped laboratory; and capable of accurately testing pressures in and outside of the laboratory, and of determining the discharging capacity of burner nipples. This latter would be the measure of the amount of gas to be paid for in the lighting contract—the Corporation having proper and efficient apparatus for doing this work.

To assist the new Lighting Superintendent to properly carry out his duties, four overseers are to be appointed, four supervisors, ten special men for the renewal of mantles, fifty lamplighters, having an average of fifty lamps each to attend to (making 180 lamplighters in all), with ten extra lighters in case of sickness. The City will be divided into four sections, having its headquarters at the district offices of the Corporation. An overseer and supervisor would be attached to each section; their duties being to take care of the pressure recorder.

In addition to this oversight and supervision, and so that the Corporation might be satisfied that the whole department was working in the most efficient manner, that the records were being accurately kept, the instruments kept in perfect order, the lights working at their best, and no excess of gas being paid for, Mr. Mansfield suggested that an independent expert should investigate and report fully once a year on the working of the whole system, at a fee of 100 guineas per annum. The brunt of the work would fall upon the new Superintendent of Lighting to be appointed; but it was not proposed to exclude the Chief Engineer from his proper share of supervision. He would deal with difficult points as they arose.

The burners to be used are to be of the incandescent type (upright or inverted) capable of consuming 3, 3½, 4, and 5 cubic feet of gas per hour at 20-10ths pressure. The burners are to have arrangements by which the nipples can be easily and quickly changed, to make the burner suit different pressures; but 20-10ths is to be the minimum pressure on which they will be used. The air inlets are not to be adjustable, as it is found that the lamplighters and cleaners are apt to interfere with adjustable openings. The quality of the Calcutta gas is of 14-candle power, when tested with the No. 2 "Metropolitan" burner, and is of rather low calorific value. The nipples for the burners are all stamped with their size legibly by a number representing its diameter in one-thousandths of an inch; the lighting hours being 3914 per annum.

This experiment will be watched by all gas engineers concerned with the question of public lighting with unusual interest, more especially in view of the magnitude of the experiment; there being some 270 miles of streets in the City of Calcutta, and the operation extending to (say) 9000 public lamps.

Charge per Illuminating Value.

Following closely on this innovation of charge of the Calcutta Municipality came, during the early part of this year, the decision of the City of Westminster, when fixing their new contracts for public lighting, to abandon the old method of paying per cubic foot of gas or unit of electricity consumed, and to inaugurate an equally new system of charge—viz., the payment per tested illumination value; the lamps, whether of gas or electricity, being tested *in situ*. Advantage being taken of the expiry of certain

electrical contracts in various parts of the city, tenders were advertised for the lighting of the thoroughfares concerned; and it was felt that it was now possible to deal with the subject in a comprehensive manner, owing to the marked improvements which have been made in recent years in the methods of producing light from gas and electricity at less cost per unit of higher power than formerly, and the still further improving of the lighting without any extra cost.

Competitive tenders were therefore obtained from the Gaslight and Coke Company and the Electric Lighting Companies for the installation of lighting units of different powers—viz., 90, 180, 300, 1800, and 3000 candles; the Council being placed in a position to select one or other of the lighting units, according to the needs of each class of street, as may be determined by considerations of width, traffic, &c. For the supply of gas or current, as the case may be, to these several units, and for maintenance, the Council obtained tenders for a term of 5, 10, or 15 years.

The Council invited the tenders on the basis of so much light for a given number of hours per annum. They contended that candle power—for instance, 90 or 3000 candles—has exactly the same value whether produced by glow-worms, gas, or electricity; and for practical purposes in the streets, the only factors were the width of the thoroughfare and the height of the column. All they had to consider was the cost of the installation and the annual up-keep cost. The test for carrying out the contract would be the portable outdoor photometer; the tests being made by the Council's officers. Under the conditions of the contract, the Company having the lighting are to be mulct in a penalty of 5s. per day for every lamp not giving the specified candle power provided by the conditions of the contract. The Gaslight and Coke Company having obtained this contract, are to replace flame arcs with high-power gas lamps. This will cause any local authorities who are about to enter on new contracts to pause and hold their hands, as they watch the results of the Westminster experiment. The largeness of the experiment, as well as the importance of the area, will cause it to be very carefully scanned. Some idea of the magnitude of the new contract may be gathered from the fact that 3056 lamps of all kinds (gas and electric), giving approximately 350,000-candle light, will be done away with and 2708 modern low-pressure inverted and 179 high-pressure inverted gas-lamps, giving about 800,000 candles, will take their place; while the annual cost will be less—viz., £14,450, against £15,642. The contract is to be based on illumination; and though many are somewhat sceptical with regard to photometrical tests of street lamps *in situ*, yet all will await with interest the results of the further investigations of Mr. Bradley (Westminster City Engineer) and Mr. Jacques Abady, the Chairman of the Works Committee, to whom are due the inception and the carrying out this new step in public lighting charge.

ILLUMINATION OF INTERIORS.

Daylight Illumination.

As announced in the "JOURNAL" for the 7th inst., arrangements were made a short time since for the delivery of three special lectures, on the "Illumination of Interiors," at the East London College, Mile End Road. The first was given on the 8th inst. by Professor J. T. Morris, M.I.E.E.; his subject being "Daylight Illumination."

The lecturer began by remarking that though the question of illumination is one with which people are so familiar in a general way that they imagine they have a very good idea of the subject, yet, as a matter of fact, there is probably not one on which there are so many erroneous ideas. In order that some of these might be removed, it was necessary that the problems involved should be approached in a thoroughly scientific manner; and though it would be impossible, in the three lectures to be delivered, to deal with anything more than outlines, it was hoped that even this would clear away some of the false impressions existing in many minds.

With these introductory observations, the lecturer proceeded to consider his subject. He pointed out that if we place a powerful electric lamp immediately in front of some reading matter, and then view the latter with the direct rays of the lamp full in our eyes, we shall observe that while the print can be read this can only be done with difficulty. The eye feels strained, and there is a natural instinct to screw up the eyelids so as to reduce the dazzling effect on the eye. On the other hand, if we place the lamp to one side and screen it, or, what is better still, place the light so as to shine over the left shoulder, it will be found that we can read with ease. In the first case, the print must have been much more brightly illuminated; and yet the lighting, from a practical point of view, was not nearly so satisfactory. This brought out the important fact that practical illumination is more a question of contrast than of absolute intensity. It is desirable, for the satisfactory viewing of an object, that all others within the field of vision should be illuminated as little as possible. And yet there are people about who do not seem to realize this elementary notion. It should further be remembered that, even if we can see "somehow," satisfactory eyesight can only be preserved by attending to questions of the nature of those just referred to. It would be very desirable, said the lecturer, if all lighting could be done on the indirect system—*i.e.*, could be so arranged that the lamps giving light—the light sources—should not be seen. This could be done by inverted electric arcs; but the method was too wasteful for ordinary purposes.

Professor Morris next passed on to remark that both candle power and illumination are comparatively easy things to measure in a properly equipped laboratory; but that until a few years ago there was no really simple and reliable method of measuring daylight. Mr. A. P. Trotter, of the Board of Trade, and Mr. P. S. Waldram have, however, devised instruments and carried out tests with them which he thought must rather startle people who have not given any special attention to the subject. Some of Mr. Waldram's results and others obtained at the East London College on the light coming from the sky and the proportion of it entering the building through the windows of different rooms were of great interest. If a sheet of printed matter were handed to a person, with the request that he would examine it first in an average lighted room and afterwards in the open air, and then state what he considered was the ratio of the inside to the outside illumination, he would probably, as a generous and outside limit, say the latter was ten times as great as the former; but, as a matter of fact, a nearer figure would be from 100 to 2000 times as great. Another important point was the wide fluctuations taking place in light during an ordinary day. The eye is only capable of following them to a small extent, and it is a very poor guide with which to judge the intensity of illumination. In this connection the lecturer exhibited a diagram prepared from measurements taken in the College grounds during the afternoon and evening of the 7th inst. It showed that the maximum light value was reached at 3500 candle-feet, and after fluctuating for several hours it gradually began to fall off until, at 6.30 p.m., the intensity was only about one-twentieth of its value at midday, while by 8 p.m. it had come down to such a small quantity as not to be recognizable on the curve plotted to the original scale. The light continued to decrease until at 9.5 p.m. it had fallen to a value of 0·02 of a candle-foot in comparison with 3500 candle-feet at midday. At 9.10 p.m. the arc lamps in the grounds were lighted, and the illumination then rose to 0·1 candle-foot. The lecturer explained that very few of these wide variations in the daylight could be distinctly observed with the eye until they amounted to reductions of several hundred per cent. This was owing to the remarkable adapting power of the eye. Calling the minimum amount of light necessary for telling the time by a watch unity, an illumination 10,000 times as great would still not seem dazzling. He thought it was doubtful whether any other organ of sense was capable of encountering such wide ranges.

The next matter dealt with was the question of window efficiency; and the striking fact was presented that the ratio between the intensity of illumination increases in a room, while that of the sky remains constant over wide ranges. This was exemplified by the tabulated results of some tests made at the East London College and in several well-known buildings. The lecturer remarked that the ratios would remain fairly constant, providing there was no direct sun on the windows, whether the day were bright or dull, or whether in full daylight or in dusk. They would depend in a large measure upon the ratio of window area to floor area; and, this being so, he thought it of interest to examine briefly the legislative and other regulations laid down on this matter. He pointed out as a significant fact that nothing was said about artificial illumination; and it was with the object of removing the widespread ignorance existing as to what constitutes satisfactory lighting under greatly varying conditions—in short, of putting illuminating engineering on a scientific basis—that the Illuminating Engineering Society had been formed. Reverting to the subject of the ratio of internal to external illumination, the lecturer said it must be remembered that while this remains fairly constant provided there is no alteration in the method of decorating the room, the latter has a very marked effect. Many people blame the architect for the bad lighting of an apartment, when probably they are themselves largely responsible for it, owing to their selection of a dark coloured paper for the decoration of the walls.

Returning to the subject of the remarkable adaptability of the eye to different intensities of light, the lecturer explained that this was made possible by the power of contraction possessed by the pupil, so that it can automatically shut out the light, and keep more or less constant the quantity falling upon the optic nerve. In order to obtain some quantitative figures on this matter, experiments were carried out at the College; and the results were given. They showed that when a person looks slightly away from the direct rays of light, the pupil opens over 50 per cent.; and the lecturer thought it was probable that in this condition the eye is more strained than when it is looking direct at the light, but with the pupil considerably contracted.

The instrument used for measuring the quantity of illumination in the experiments referred to was Mr. Trotter's daylight photometer, a description of which brought the lecture to a close.

We have received from Messrs. J. G. Hammond and Co., Limited, of Birmingham, Section I. of their "Miniature Pocket Directory of Gas Undertakings for 1910." It includes particulars in regard to all the gas undertakings in Great Britain and Ireland, corrected to date from special information received. The book consists of 48 pages of tables (8 in. by 5 in.), which in two folds are brought down to a convenient size for the pocket. The particulars furnished comprise the name and population of each town, the names of officials of the undertaking, financial and working statistics, number of consumers, and prices charged,

THE QUALITY OF LIGHT.

The above-named subject formed the basis of a lecture delivered a short time ago before the Franklin Institute, Philadelphia, by Mr. PAUL F. BAUDER. It contained much matter which has come before most of our readers in various ways; but it may be of interest to reproduce some portions of it.

The lecturer began by remarking that as new illuminants have been placed upon the commercial market, the question has arisen as to the relative value of the light given by them as an artificial duplicate of daylight. Such a broad use of the term "daylight" had, he said, led to much discussion between the advocates of each artificial light source; and it was his purpose to submit the results of some investigations upon which an estimate could be formed as to the comparative merits of each of the more common commercial illuminants. Daylight was the only natural light source; while under the heading of "Artificial Illuminants" might be placed all those which have been in use from the beginning of time. The qualities which mark the sun as the ideal illuminant for the majority of conditions, might be classified under the following headings: Intensity, colour value, direction of rays, ability to reveal detail, and adaptability. These qualities the lecturer proceeded to consider separately.

Dealing first with the intensity of daylight illumination, Mr. Bauder pointed out that the sun is brightest at noon; in other words, it is at its maximum intensity when there is the smallest chance for its direct rays to enter the eye and injure the retina. At sunrise and sunset, however, the rays of light come in a horizontal direction, and are therefore more liable to cause injury to the delicate interior of the eye. At the same time, the organ will adapt itself to great changes in the intensity of daylight. With regard to colour, daylight is composed of varying proportions of the seven primary or fundamental colours; and its greatest variation in quality may be attributed to the different percentages of these colours. In all forms of daylight, a certain relationship exists between the different component colours. The directional relation of natural light plays a very important part in the general appearance of any surroundings. Maximum daylight is usually received in a plane approaching more nearly the vertical than the horizontal; causing shadows and high lights to appear in correct proportion. On the other hand, an extremely flat effect would be caused by a light with almost complete diffusion. The question of having the proper direction of light in order to make objects visible and reveal detail has a direct bearing on visual acuity. The important requirement for a light is that one may be able by it to distinguish colour values, fine detail, &c., with the proper intensity and direction.

The qualities of efficiency and steadiness of light production may be grouped under the heading of "Adaptability," inasmuch as all light should be readily adaptable to meet various requirements. The light from the sun was primarily used for purposes of mechanical labour, where the necessity of revealing fine detail, obtaining proper colour quality, and intensity were not needed to so great a degree as they are at the present time. On account of the requirements which have been developed in the progress of civilization, daylight has failed to answer for all purposes, due to the fact that our vocations must be pursued at all times without depending upon daylight. For this reason the adaptability of all sources of light, both natural and artificial, must be given proper consideration. It has been necessary to use prismatic glass, and to adopt an entirely new construction of building and skylights, in order to use natural daylight for such classes of effort as are generally undertaken for manufacturing and industrial purposes. It is true that artificial illuminants must be adapted for more diverse purposes than daylight. They must likewise be directed in such a manner as to meet all interior requirements. Practically all commercial illuminants have been designed with this thought in mind. The ideal light source, on the other hand, must have such qualities of colour and ability to reveal detail, such intensity and direction of maximum rays, as to make it capable, in all conditions of service, of meeting certain requirements depending on the conditions surrounding the work for which they were intended.

Having indicated the various characteristics of daylight, the lecturer proceeded to compare them with the similar qualities of various illuminants, with the object of determining, from the standpoint of adaptability, which is the best for use under certain conditions. This part of the lecture is given practically in full.

The illuminants compared were the following: Carbon treated filament lamp; carbon untreated filament lamp; "Gem" metallized filament lamp; tantalum filament lamp; tungsten filament lamp; Nernst lamp; enclosed arc; upright gas arc; and inverted gas arc. The light flux of all these lamps was so different, that no attempt was made to determine their candle powers. The endeavour was to obtain the actual effects of the quality of light produced by these sources. The brilliancy of any of them is so far below that of the sun, that the impossibility of obtaining comparisons in intensity between them and the sun is apparent.

In referring to the intensity of the light sources investigated, the advisability of placing one of high intrinsic brilliancy a sufficient height above the floor level of any space, in order to benefit by the principles previously noted regarding the sun, is self-evident. An alternative, likewise possible, is to reduce the intrinsic brilliancy of the source by using glassware of proper design and intensity to increase the diffusion of light and to decrease its brilliancy. By the use of this principle, the necessity of resorting entirely to height in order to produce a sufficient diffusion of light is eliminated.

The question of the colour value of given commercial light sources is one which has caused more diverse opinions to be raised than any other quality of artificial illuminants. All artificial light sources have a characteristic quality of colour which is apparent from observation. The colours of the illuminants investigated may be tabulated as follows:—

Designation.	Colour.
Carbon (new)	orange-yellow.
,, (seasoned)	yellow.
,, metallized (new)	pale yellow.
,, metallized (seasoned)	yellow.
Tantalum (new)	yellow-white.
,, (seasoned)	lemon-yellow.
Tungsten (new)	cream-white.
,, (seasoned)	yellow-white.
Nernst lamp (new glower)	pale lemon-yellow.
,, ,, (seasoned glower)	deep lemon-yellow.
Enclosed arc (opal outer, clear inner globe)	bluish-white.
Gas arc, upright (new mantle)	pale greenish-white.
,, ,, (seasoned mantle)	pale greenish-yellow.

The colours of these sources are not readily apparent when used for general illumination purposes. Nevertheless, when a given series of colours is viewed beneath the light from any one of them which in each case is compared to the similar result under daylight illumination, it is evident the effects produced vary a great deal from the true colour values as seen under daylight illumination.

The true importance of obtaining the best form of illuminant, in order to give the most desirable and attractive results for all classes of service, may be observed when a comparison is made between the colour effects produced by a carbon and tungsten illumination and daylight. The results show that a surprising advance has been made in the incandescent lamp industry in the endeavour to get a type of lighting unit which would cause objects to appear more nearly natural under artificial illumination.

Not only for store lighting, but likewise for residence lighting, the production of the proper colour values and of the proper intensity and direction of light to give a pleasant appearance to interiors should be the general aim for all users of artificial light. Not only from the standpoint of the merchant, but likewise from that of the architect, the interior decorator, and the furnisher, there is necessity for obtaining the best means to advance his efforts in artistic lines. This view should not be limited to mere financial ends for the use of light, but a lasting benefit should be gained by improving the standards for all classes of human effort in art and decoration as well as commercialism.

It has been shown that, from the standpoint of direction of light, there must be, for satisfactory illumination, not a complete diffusion, but a balance giving the proper proportion of light and shade. In order to obtain a true determination of how different interior decorations are affected by the use of light of varied colour quality, the effect accentuated to a certain degree may be observed by projecting on a coloured curtain the three primary colours of light—red, green, and blue. If the colours on the curtain and the primary colours of directed light were pure or free from a combination of colour pigments forming them, the lines which were not illuminated by a light of a corresponding colour quality would appear black. This is easily appreciated, for the colour which is seen is only the impression received upon the retina of the eye by wave-lengths of light which have not been lost by absorption after falling upon the coloured surface. The necessity for obtaining a proper proportion of colours forming the light flux emitted from an ideal artificial light source, whether alone or with the aid of glassware, is apparent. This proportion might not be that of daylight, but the colours composing the ideal light source should be such that there would be an equal or equivalent percentage of each of the fundamental colours.

It is evident that the æsthetic tastes are sometimes appealed to by an incorrect use of illumination, in order to impress the observer with the beauty of surroundings. A more useful result would, however, be obtained by making the most practical efforts to impress the user of artificial light with the necessity for living and working to his best advantage under conditions requiring the use of artificial light. Owing to the inability of natural light to meet our modern requirements for constancy of intensity, colour value, &c., it is obvious that artificial light sources correctly applied must be adopted.

It has been shown that some of the investigated sources are better for one condition of service than are others; and it must be concluded that the best artificial illuminant at present upon the commercial market is that which is adaptable to the largest number of classes of service, providing that it maintains a high standard of the before-mentioned qualities of light.

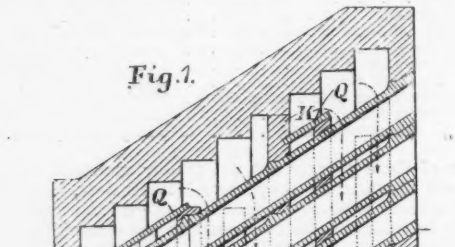
The importance of obtaining the best possible illumination can be better appreciated when it is considered that, at the present time as never before, there is in the minds of most people a broader comprehension of what constitutes good illumination. The five qualities of the ideal light source should not be overlooked, for many thousands of dollars are spent annually on the production of pleasing lighting effects. If these can be improved, and the art of illumination placed upon a higher plane, we are effecting material progress.

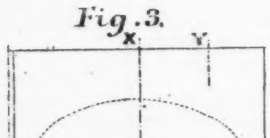
HEATING RETORT-SETTINGS.

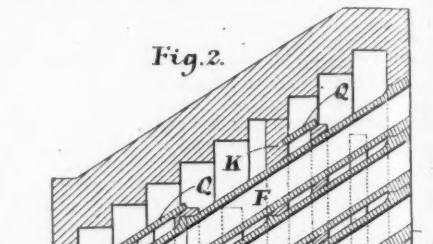
The specification has lately been published of a patent taken out for France by MM. Stein et Cie. for a method of heating inclined or horizontal retorts for the distillation of coal or any other material. The setting is heated by three rows of nostrils—two being placed before it, perpendicularly to the front, and the third in an intermediate position. The front part of the retorts is heated by the two first-named rows of nostrils, and the products of combustion mix with the flames coming from the other nostrils and heat the back part.

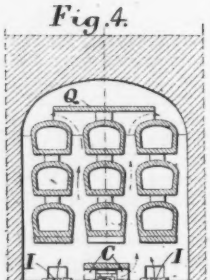
The arrangement is shown in the accompanying illustrations, in which figs. 1 and 2 are longitudinal sections of the setting—the former on the line X and the latter on the line Y of fig. 3, which is a front view. Figs. 4 to 8 are sections of fig. 1 and fig. 9 is a half back view of the setting.

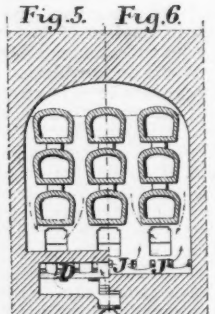
The gas generator A is similar in construction to an ordinary generator. The gas produced flows into the chamber B, which communicates with the combustion chambers by means of the openings C D, which are provided with dampers E. The gases produced in the generator pass into the combustion chambers by two series of nostrils, following the course indicated by the dotted arrows. In the combustion chambers are the retorts F, in which the coal or other material is carbonized. At the back of the setting is the recuperator G, which is heated by the burnt gases coming from the furnace. The recuperator heats the air for supporting combustion at the nostrils. The conveyance of the

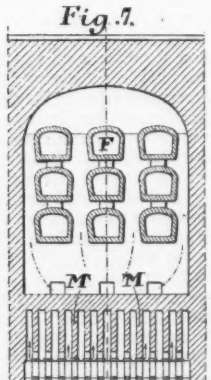


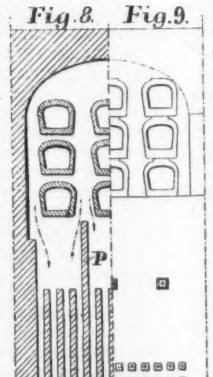












heated air into the front combustion chambers of the setting is effected by the channels H and openings I, furnished with dampers. The combustion of the gas coming through the openings D is supported by a current of hot air, which comes from the recuperator and enters the combustion chamber by the openings J. The course taken by the air supplied to the nostrils is shown by the full arrows.

In the portion of the furnace in front of the partition K, heating is effected by means of the gas entering by the openings C in presence of the air arriving by the openings I. Combustion takes place first in ascending and afterwards in descending flames, as shown by the broken arrows. The retorts between the partition K and the back of the setting are heated by the combustion of the gas coming from the openings D. This is supported by the secondary air coming from the openings J. With the jets of flame thus obtained are united the fully burnt gases resulting from the primary combustion. Heating is effected as in the front portion of the setting—viz., first by ascending and afterwards by descending flames. The products of combustion pass through the recuperator G in the direction shown by the broken arrows in fig. 1, then into the flues L, and escape by the chimney.

The lower part of the recuperator is divided into three separate

chambers by partitions M, the outer ones conveying hot air to the openings I, and the openings J receiving hot air from the central chamber. Three bye-passes N allow the air conveyed to each group of openings to be exactly regulated; and the production of gas can be regulated by opening more or less the three dampers O. By means of these, the flames can be made to pass as required either to the centre or to the sides of the furnace. For this purpose, they are provided with partition walls P, the tops of which are near the retorts. Slabs Q placed above the retorts deflect the flames on to the portion of the retorts heated by the ascending flames.

CORROSION OF INDUSTRIAL IRONWORK.

At a recent Meeting of the Birmingham Section of the Society of Chemical Industry, a paper on this subject was submittted by Messrs. A. R. Warnes and W. S. Davey. They thought that a short paper dealing with some of the most important cases of corrosion of iron which had come under their notice would stimulate other workers to publish their experiences, and so ventilate a matter of extreme importance to people connected with the chemical and engineering industries. The following are the portions of the communication (the text of which is published in the current number of the "Journal" of the Society) which are of special interest to our readers.

Considering its importance, the literature on the subject of the industrial corrosion of iron appears to be very scanty. Iron is acted upon by very dilute solutions of calcium chloride, sodium chloride, potassium sulphate, and calcium nitrate, and the action becomes more pronounced in the presence of carbon dioxide. Carulla, in a paper on the "Corrosion of Iron by Raw Tar," he read before the Nottingham Section of the Society in 1896,* calls attention to two bolts taken out of the valve-box of a pump that raised water from a well to supply a works. These bolts, which were originally 1¼ inches thick, had become badly corroded, the erosion in some parts being ⅜ inch in depth. The corrosion was supposed to be due to something communicated to the water by tar, as tar residues existed on the surface soil. Bolts in a pump used to raise tar at the same works were similarly corroded. Ammonium chloride was supposed to contribute to the corrosive action in both cases. In several cases brought under our notice, and also in our own experience, we have not found the internal parts of tar-pumps suffer from any marked corrosion, nor in one case of a water-pump which raises approximately 40,000 gallons per day of water contaminated with tar products. A portion of the end of a knocking stud taken from a tar-pump after being in use for upwards of five years showed practically no signs of any corrosion.

Herr Donath, in a paper on the "Production of Ferro-Cyanogen from Gas-Liquors,"† states:

> We can see easily that gas liquors exercise a corrosive action on iron; but this action apparently is more energetic when the water is heated. While the pumps which are used to pump up the cold ammoniacal liquor are corroded but slightly, it is by no means uncommon to observe strong corrosive action on the iron portions of the distilling apparatus. I have even seen . . . a Feldmann distilling apparatus which had become so completely friable that at many places it was easy to pierce the thick sides with an ordinary knife. A portion removed with a knife consisted principally of graphite and prussian blue; and it is highly probable that this latter body was formed, thanks to the presence of sulphides in the gas liquors, by the same process as in the purifying material.

In regard to the action of cold ammoniacal liquor on the iron portions of pumps, we can confirm Lange's observations. In a valve taken from a pump which has constantly pumped ammoniacal liquor for over 3½ years, the greater part of the valve face still exists. Hence it may be concluded that cold ammoniacal liquor is not a serious corrodent so far as iron is concerned. The corroded parts of the valve have taken on a granular appearance. We are also able to partly confirm the same worker's observation that portions of the cast-iron columns of ammonia stills are corroded, in many cases becoming cellular; portions of the iron being eroded, and leaving cell-like spaces. We cannot confirm the presence of prussian blue in the corroded parts.

Carulla finds cast-iron everlasting when used for ammonia stills; and he instances the case of a still which had been at work for eighteen years, the numerous cast-iron cylinders of which showed no signs of wear. He also calls attention to the possibility of ammonium chloride attacking the iron of which tar-stills are constructed, and the marked corrosion taking place in castings of iron containing wrought-iron chaplets when they are brought in contact with many chemical liquids.

When dealing with the corrosion of tar stills, we shall have occasion to refer to the part which ammonium chloride plays in that action; but in this place we should like to confirm Carulla's observations in regard to wrought-iron chaplets in castings. It was found that the cast-iron pipes used to connect the swan-necks of tar-stills to the condenser coils rapidly corroded at the point where the chaplets had been introduced, and in some cases the chaplets were eaten right out. It is most likely that the rapid corrosion which takes place at the chaplets is due to marked local electrolysis; corrosion of all metals being probably more or less due to electro-chemical action. A remedy was found in this case by using pipes which were cast vertically without the use of chaplets.

To the tar distiller, the corrosion of his stills is a continued source of anxiety and expense; and he would welcome an alloy at a reasonable price that will resist for a longer period than wrought iron or mild steel the corrosive action of the vapours which are given off during the distillation of tar. The mechanism of the process of corrosion of the iron of tar-stills is, without doubt, a complicated one; and it is somewhat difficult to form a theory to fit in with all the conditions that may exist in the still from the commencement to the finish of the operation. We are of the opinion that the dissociation of ammonium chloride, ammonium sulphide, ammonium hydrosulphide, and ammonium cyanide, and the subsequent action of the dissociation products upon the iron, is the chief cause of the corrosion. The rate of the action is probably increased by electro-chemical conditions (self-corrosion). It is quite possible also that strain contributes towards corrosion by producing a certain amount of molecular instability in portions of the iron plates; thus rendering these parts more easy of attack. The plates are eaten away at a greater speed at the points where excessive condensation takes place—for instance, under the manlid-stool; and this is due, probably, to the continuous flow of liquid removing the final products of corrosion more rapidly at these points than they are removed elsewhere, and thus exposing a fresh surface of iron to the attack.

It is thought that the process of corrosion goes on at a greater rate during the latter portion of the distilling operation, principally during the period when steam is used to assist in the distillation. The final products into which the corroded iron is converted appear to be chiefly ferrous sulphide and ammonium ferrocyanide. Ammonium thiocyanate occurs in small quantities, and traces of ferrous chloride and prussian blue have been found in portions of the corroded iron. It is considered that the steam introduced into the still plays no other part than that of producing ionization of the ammonium chloride, &c., and increasing the power of action of the products of dissociation.

As far as possible, it has been endeavoured to prove the theories just enunciated. To secure in glass apparatus like conditions to those existing in a tar-still during work, is next to impossible. On the under sides of manlids of stills after working, a deposit of a dirty brown colour was noticed, Several samples of this material were collected and examined, when it was found that more than 50 per cent. consisted of ammonium chloride. The carbon appeared to be in the graphite state, and contained a trace of iron. In the water soluble portion, which was faintly acid to litmus paper, a trace of ferrous iron and a large trace of sulphates were found in addition to the ammonium chloride. Ferrocyanides and thiocyanates were absent. Large quantities of ammonium chloride and ammonium sulphide were found in some of the liquors which come over during the working of the still. It is a well-known fact that ammonium chloride and ammonium sulphide dissociate at high temperatures into ammonia and hydrochloric acid, and ammonia and sulphuretted hydrogen respectively; and it is quite reasonable to suppose that the hydrochloric acid and sulphuretted hydrogen set free will attack the iron of the stills, especially in the presence of steam which is to a certain extent superheated owing to the temperature of the still. It is considered that ammonium chloride exerts a greater action upon iron than ammonium sulphide; and the fact that traces of ferrous chloride were found in the scrapings taken from plates in different parts of stills, supports the theory that ammonium chloride plays an active part in the corrosion.

The results of an examination of the ammoniacal liquors which distil over during the proces of tar distillation are given in the following table. It will be noticed that the amounts of ammonium chloride and of iron as ferrocyanide (expressed in grammes per 100 c.c.) are greatest in the liquor which comes over during the end of the distillation. It is at this stage that steam is passing into the still and the temperature is high; and it seems quite within reason to assume that the action of corrosion is at its height during this period.

	Ammonium Chloride.	Ammonium Sulphide.	Ammonium Ferrocyanide.	Ammonium Thiocyanate.
Liquor collected—				
When still commences to work	0·130 ..	0·40 ..	Trace ..	Trace
At finish of crude naphtha	0·053 ..	2·20 ..	0·040 ..	,,
During working of heavy creosote (steam passing into the still) . .	2·020 ..	0·54 ..	0·056 ..	Large trace

The final products of corrosion are found chiefly in the shape of loose scale on the plates. Small quantities occur in the oils which distil over, and in the ammoniacal liquor—in the former case as ferrous sulphide in the form of a fine black powder or in coagulated masses, in the latter as ammonium ferrocyanide. An examination of the scale removed from several plates in various positions showed ferrous sulphide as the chief final product. Ferrous chloride and prussian blue occurred in small traces.

* See "Journal," Vol. LXVIII., p. 73.
† *Ibid.*, Vol. LXXVIII., p. 1663.

STUDIES IN THE MANUFACTURE OF COAL GAS.

At the Meeting of the Michigan Gas Association in 1907, a paper on this subject was submitted by Messrs. Alfred H. White and Frederick E. Park; the latter being the holder for 1906-7 of the Association's Fellowship in Gas Engineering at the University of Michigan. The paper was the seventh to be presented to the Association as the result of its support of the fellowship. At the previous annual meeting, it was resolved to erect experimental plant in connection with the works of the Ann Arbor Gas Company, where the factors influencing gas manufacture and purification might be more closely controlled and better studied than had been possible in tests made on full-sized plants. The Committee having charge of the matter decided that the plant should consist of complete condensing and purifying apparatus designed small enough to be suitable for the investigation of the products from a single retort; and it was quite hoped at the time that it could be equipped within a few weeks. The manufacture of the special apparatus, however, went but slowly; and it was not till the spring of 1907 that the completed plant was ready. The paper submitted later in the year, which was given in the "JOURNAL" for Oct. 8, 1907 (p. 101), was in the nature of a preliminary report on its operation. At the meeting of the Association last September, a second paper on the subject was presented by Mr. White, in association with Mr. W. A. Dunkley, the holder of the fellowship for 1908-9, Mr. J. H. Wyman, who held it the preceding year, and Mr. Percy Barker, an Assistant-Engineer in the Technological Branch of the United States Geological Survey. The text of the paper was not available at the time; but the Secretary of the Association (Mr. Glenn R. Chamberlain, of Grand Rapids, Mich.) has since forwarded us a copy, and we are thus able to give the following extracts.

INTRODUCTION.

The present paper is the ninth to be presented to the Michigan Gas Association as the result of your support of a fellowship in gas engineering at the University of Michigan. Two years ago, the paper presented by Messrs. White and Park was the result of a year's preliminary work at the experiment station established by you at the works of the Ann Arbor Gas Company. It was intended that this should be simply a preliminary report to show the construction, method of operation, and possibilities of the plant, and not a statement of final results. The following year was spent in bringing the plant into more reliable working condition; new equipment being added and alterations being constantly made in equipment and method of operation to make the results mor accurate. In the summer of 1908, it was believed that the pla had been brought to a point where it could be used for systematic research work.

At this time, we were fortunate enough to obtain the co-operation of the Technological Branch of the United States Geological Survey. The Geological Survey agreed to send one of their field inspectors to sample the mines from which coal was desired, to deliver the coal at the testing plant free of charge, to make all chemical examinations of coal and coke samples, and to station one of their assistant engineers at Ann Arbor during the college year 1908-9 to assist in the work. This not only made it possible to obtain coal samples with authentic histories, but also added greatly to the amount of work which could be done at the plant. The present paper represents, then, two years of work at the experiment station, but contains only data obtained during the last year. The work of the preceding year was no less carefully performed; but on account of the development of the testing plant, the results were not so satisfactory as are the later ones.

DESCRIPTION OF EXPERIMENT STATION.

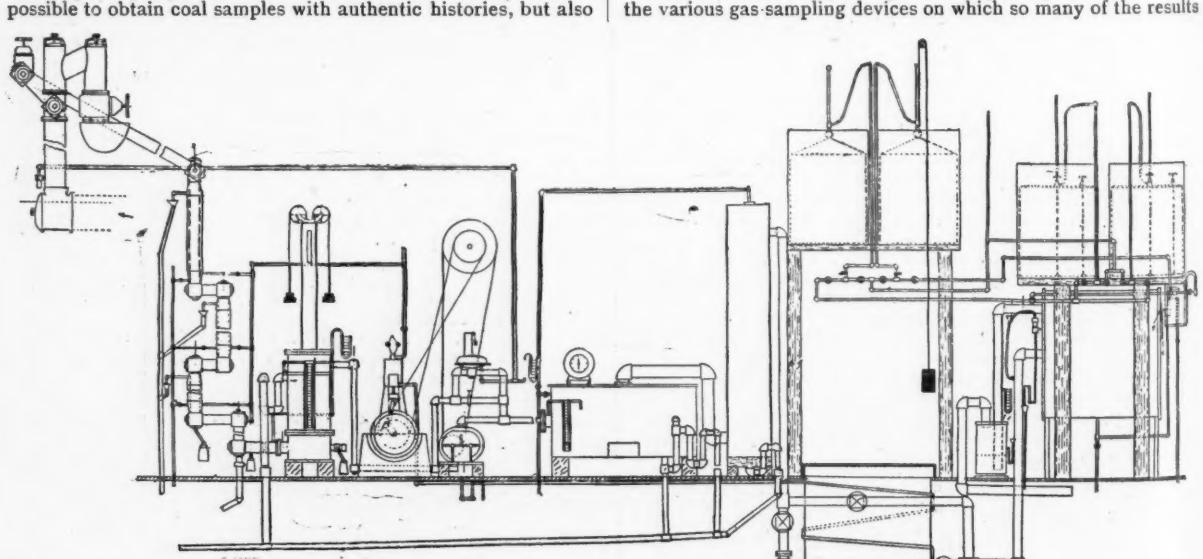
The experiment station was described and illustrated in the preliminary report made to you two years ago, and it does not seem worth while to publish again a full description of it. It seems wise, however, to briefly present enough of the general arrangement to make this paper intelligible without reference to the earlier one, and to report on the changes that have been made for the betterment of the work during the past two years, for the benefit of the members of the Association who are interested in the progress of the plant.

The gas is taken from a single retort 26 in. by 16 in. by 9 ft., which is one of the upper retorts of a bench of six, with three-quarter depth regenerative settings in the retort-house of the Ann Arbor Gas Company. This retort is in regular work; and when it is desired to use it for experimental purposes, it is isolated from the Company's mains and connected to the experimental plant immediately adjoining. The equipment of this plant (shown in elevation in the accompanying diagram) consists of a condenser, a Pelouze and Audouin tar-separator, exhauster and engine, tar-washer, ammonia-scrubber, oxide of iron purifier, and station meter, together with the necessary sampling equipment and a laboratory for the determination of candle power, heat value, and for chemical examinations.

Although the general arrangement of the plant is the same as it was two years ago, nearly every piece of apparatus has been modified one or more times since its installation. The temperature of the retort, both inside and outside, is now measured with a pyrometer, and the pressure is controlled by a diaphragm governor acting on the exhauster bye-pass. Satisfactory valves have been installed for isolating the experimental retort; and the foul main has been jacketed to avoid sudden cooling of the gas. The condensers have been changed to three vertical units, with an annular space in which either cold or hot water can be circulated, so that the gas can be brought to the inlet of the tar-separator under fairly well-controlled conditions. This has had a lighter drum installed to make it more sensitive.

The greatest trouble has been experienced in obtaining a satisfactory exhauster. The amount of gas to be handled is small, and varies during the test from a possible maximum of 12 feet per minute to a minimum at the end of the run of 1 foot per minute. The slow-speed exhauster first used transmitted positive and negative modes of pressure which showed fluctuations as rapid as an inch of water pressure at the retort. Three separate exhausters and several modifications of governors have been tried in the effort to overcome this difficulty. In the present arrangement, a small rotary blower is run at about 400 revolutions a minute with a primary bye-pass operated by a hand-wheel for coarse regulation, and with a secondary bye-pass controlled by a modified diaphragm governor which is actuated by the pressure of the gas in the retort to which it is directly connected by a ¾-inch pipe. This arrangement is not perfect, for the leather diaphragm in contact with unpurified gas soon stiffens, and does not respond quite so rapidly as the fluctuating speed of the engine requires. But with care it has been possible to operate it so that the pressure has never for more than a minute at a time varied over 1-10th of an inch of water pressure from the 1-10th back-pressure which it is aimed to maintain on the retort.

Much attention has been paid to improving the accuracy of the various gas-sampling devices on which so many of the results



The Equipment of the Experimental Plant Employed.

depend. The tanks which sample the gas by half-hour intervals have given relatively little trouble, for there is not much variation in the rate of gas production or in its quality during a single half hour. The contrary is the case, however, with the proportional tank, which is supposed to collect a mixed sample representative of the whole of the gas from beginning to end of the run. This tank is filled by a small wet meter working as a pump, and geared to the shaft of the station meter, so that an aliquot portion of all the gas made is forced by it to the proportional tank. So far as appearances go, the arrangement works well; but the results obtained for the proportional tank do not check as they should do the figures for chemical composition and heat-value calculated from the half-hour tanks. The proportional tank usually gives high results, which causes the belief that the proportional meter lags at the extremely slow speeds at the end of the test, and does not deliver the proportionate amount of the poor gas at this period. It is possible also that incomplete mixture of heavy rich gases in the bottom of the proportional tank with the light poor gases on the top has caused part of the trouble. It is proposed to instal a larger proportional tank, which will allow the meter to run faster; and it is hoped the other difficulties may also be overcome.

The equipment of the laboratory now includes an excellent bar photometer, a Junkers calorimeter, a complete gas analysis outfit, a Drehschmidt apparatus for ascertaining the total sulphur in purified gas, two Hoskins pyrometers, and a Morse thermo-gauge, lent by the manufacturers, for the optical measurement of retort temperatures. All chemical work which does not have to be done on the spot is performed in the chemical laboratory of the University of Michigan, in quarters set aside especially for the work. During the past year, the analyses of all the coals and cokes were made at the Pittsburg Laboratory of the United States Geological Survey.

Scope of Experiment.

In the study of a complex problem which presents as many variables as does the destructive distillation of coal, it is not wise to omit any test which can possibly be of service. The aim has, therefore, been to collect all experimental data which could have a bearing, and to put quality of work ahead of quantity. The equipment of the plant is such that it is possible to study the effect of changes in the method of operating the retort or the condensing or purifying system when working with a single variety of coal, or to study the behaviour of different coals when tested under the usual conditions of practice. It was recognized that both of these studies were worth making, and, in fact, that they were so closely intertwined that it was impossible to completely separate them. But as the interests of the Geological Survey lay in studying the coals of the country, it was decided to spend the year in testing different coals, in order to ascertain whether there were other coals than those at present being used for the manufacture of illuminating gas which might be so utilized.

The first list of coals was made up after a study of the records of the coking division of the Geological Survey, and only such coals were included as had shown in the coking tests that they were available from this standpoint, and whose proximate analysis and percentage of sulphur indicated that they might be available for the purpose of the investigation. It was also deemed desirable to get samples of coals from widely-separated areas of the United States. It was hoped that in this way not only would the attention of gas engineers be attracted to coals not now used as possibilities, but that the data compiled from a large number of these tests might also be useful as a basis for a study of the phenomena taking place in the retort.

Method of Conducting Tests.

The method of conducting the tests will be described in some detail, to show the precautions taken to get reliable results. The coal was usually shipped by the Geological Survey inspector in canvas sacks holding 100 lbs. each; and 3 tons were sent from each mine. Occasionally this had been screened at the mine before shipment; but as many of the mines were unprovided with screens, much of it came as run-of-mine coal. The rough handling received by the coal in shipment in sacks broke it up considerably; so that to make all tests comparable from the standpoint of size of coal charged into the retort, the coals were screened (except on the first few tests) before charging. A standard screen as used at the mines in the preparation of gas coal was made 2 feet wide and 6 feet long, of ¼-inch bar iron spaced to ¾-inch and set at an angle of 30 degrees. The fine coal which fell through this screen was rejected, though screenings were frequently sampled and analyzed to determine the effect of screening on the composition of the coal.

Before starting the regular test, a preliminary charge of 400 lbs. of coal was carbonized for four-and-a-half hours—to fill all parts of the condensing system with the products of this particular coal, and to see that everything was in order. None of the test observations were taken; and the condensed tar and liquor were allowed to flow into the tar-well of the city works. During this period, the jars for the collection of tar and liquor were tared and tagged, the gas sampling tanks and vessels were filled with water, the sampling apparatus for ammonia and naphthalene in the gas put in place, the coal for the test proper weighed up, and the pyrometer for the measurement of the temperature in the fire-space surrounding the retort inserted through the hole in the end wall of the setting opposite the middle of the retort until the thermo-couple was about 1½ inches from the retort.

In the interval while the coke of the preliminary test was being drawn, the valve into the tar-well was closed, the tar which had accumulated in the Pelouze and Audouin tar-separator was drawn off, and the tar-separator itself was filled to overflowing with fresh ammoniacal liquor from the works, the jars for the collection of tar and liquor were put in place on the condenser, and the hands of the station meter were set to zero.

While this was being done in the experimental plant, an operator in the retort-house was supervising the charging of the test retort. The retort was first examined to make sure it was clean and in serviceable condition, and the car of coal containing the exact weight to be used was then brought up and charged by the regular stokers in the usual manner—all of the coal on the car being thrown into the retort. As soon as the mouthpiece was closed, the rise in pressure on the gauge in the experimental plant gave the indication to the operator there, who at once started the engine. The pyrometer to measure the temperature on the inside of the retort was then put through the hole in the mouthpiece, and pushed back until the unprotected thermo-couple was lying on the coal half-way between the front and the back of the retort. It was then luted in; and when the operator had made sure that the mouthpieces and all connections were tight, he returned to the experiment station.

In the experimental plant the speed of the engine was regulated so that the manometers showing the pressure upon the mouthpiece of the retort and at the inlet of the Pelouze and Audouin tar-separator showed a back-pressure of about 1-10th inch. So long as both manometers gave concordant results, it was proof that there was no stoppage between the two points. After the pressure had been regulated by means of the engine throttle and the gate-valve on the bye-pass of the exhauster, the diaphragm regulator controlled the pressure quite automatically. As the yield of gas dropped off near the end of the run, it was necessary to open the gate-valve on the bye-pass more and more, thereby allowing the gas to circulate more freely through the bye-pass and diminishing the suction on the retort.

The collection of tar and ammoniacal liquor, and the registration of the gas made, started automatically as soon as the retort was closed; and the apparatus for testing the ammonia in the gas at the inlet of the Pelouze and Audouin separator and the naphthalene in the gas at its outlet were also started promptly at the beginning of the test. However, since the system had been filled with air while the coke of the preliminary charge was drawn, five minutes' interval was allowed to elapse before the gas for candle-power and heat-value tests was turned into the sampling tanks.

The division of duties among the testing crew was as follows: One man read the station meter every five minutes, and he also recorded the pressures shown by the gauge on the diaphragm governor line from the standpipe, the pressure at the inlet of the Pelouze and Audouin separator, the differential pressures on the Pelouze and Audouin separator and tar washer, and the pressure at the meter outlet. A second man every five minutes read temperatures at the inlets of the three units of the condensing system, at the inlet and outlet of the Pelouze and Audouin separator, and he took the temperature of the water of the station meter and of the gas leaving it. This man was responsible for the regulation of the condensers. By the use of cold water on the condensers, it was possible to keep the temperature at the inlet of the Pelouze and Audouin separator from rising above 120° Fahr. after the first few minutes of the test. As the test progressed, and still less steam came over to be condensed, the water was cut off. Towards the close of the test, steam was turned on the condensers; and at the last, even with full steam, it was not possible to keep the temperatures above 100° Fahr.

The sampling of ammonia, tar, and naphthalene present in the gas at the Pelouze and Audouin tar-separator kept one man extremely busy, and requires further description. It was necessary to deviate from the usual works' practice of determining the amount of ammonia in the liquor flowing from the separator and scrubber, because of the large volume of liquor present in these pieces of apparatus at the beginning and end of the test as compared with the volume collected during a five-hour test. The ammoniacal liquor from the condensers was collected each half-hour; and the ammonia in the gas at the outlet of the condenser was determined by sampling the gas at the inlet of the Pelouze and Audouin tar-separator. This was done by drawing a portion of the gas through bottles containing dilute acid. The aspirator tanks used for this purpose held approximately a cubic foot of gas, and were set to empty in half-an-hour; the exact time of starting and finishing each being recorded. After analysis, the quantity of ammonia in the whole of the gas was computed from the station-meter readings, and allowance was made for the few minutes interval between tests. These figures were, for ready comparison, calculated to even half-hour intervals.

The naphthalene in the gas was determined in a similar manner at the outlet of the Pelouze and Audouin separator, and sometimes also at the inlet; the tar fog being filtered out by an asbestos filter, and the naphthalene in the gas being scrubbed out by an acetic acid solution of picric acid. The methods for determination of naphthalene were those which were devised several years ago in connection with this same work.* After analysis, the results were computed for even half-hours as for ammonia. On account of the great analytical labour involved, the naphthalenes in the tar fog and gas at the inlet of the Pelouze and Audouin

* "Journal" Vol. LXXXVIII., pp. 262, 323; Vol. XCII., pp. 388, 466.

separator were determined in a few instances, and those at the outlets in only about half the tests. For the same reason the naphthalene dissolved by the tar in the condenser and the Pelouze and Audouin separator was determined only on an average sample of the combined tars for the whole distillation period.

Hydrogen sulphide was determined in the later tests in the gas leaving the ammonia scrubber by bubbling a portion of the gas slowly through ammoniacal cadmium chloride and then through an experimental meter. The usual lead acetate test for hydrogen sulphide in the purified gas never disclosed its presence.

The two tanks for sampling the purified gas were used alternately and changed exactly at the close of each half hour. They were connected with the laboratory above, where determinations were made of heating value and candle power. Any error due to solubility of the varying gases in the calorimeter and photometer meters was avoided as far as possible by allowing the gas to flow through the meters for fifteen minutes to saturate the water before commencing a test. The candle powers reported here were made with a Sugg "D" argand; the standard source of light being a Hefner lamp. The heat values were determined with a Junkers calorimeter. No attempt was made at gas analysis during the half-hour intervals. The samples for analysis were preserved in glass gasholders, which prevented leakage and left only a small amount of water in contact with the gas; so that it could safely be preserved for 24 or 48 hours if necessary before analysis.

The standard test charge of 400 lbs. of coal was usually carbonized in four-and-a-half hours; but in case a longer time was needed, it was allowed—carbonization being continued till the evolution of gas had dropped to about one foot per minute from the 400-lb. charge. The coke was then drawn by the regular stokers into a special buggy placed just below the mouthpiece of the retort, and weighed at once without quenching. It was then quenched and allowed to stand in the buggy for two or three days and re-weighed. It was expected to obtain some idea as to the relative amounts of water which the coke from the various coals would retain; but it was found necessary to drown the coke so completely (to prevent its catching fire) that it absorbed exorbitant amounts of water, which it still retained on the second weighing. So that the figures on quenched coke have little value. The wet coke was then screened over the ¾-inch bar-screen in the same manner as the coal, and a representative sample was sent to the Geological Survey laboratories for analysis.

Computation of Results.

Since this paper presents a study of the products of destructive distillation of coals of different composition, especial care has been taken to set forth their differences as fully as possible. Most people will probably consider that a study of the products of distillation should be based on the unit weight of coal charged. Some will prefer to base the computations on the unit weight of dry coal; and from the standpoint of scientific study of products of distillation, the study can best be made on a basis of coal free from moisture and ash. Both the proximate and the ultimate analysis of the coals have accordingly been calculated in these different ways, and the whole mass of material, together with notes on the geographical source of the coal, are incorporated in an appendix. In the same way, the products of distillation have been calculated to a basis of coal as charged, dry coal, and coal free from moisture and ash. These also form part of the appendix.

All operations during the test were made to coincide so far as possible at even half-hour intervals. It was feasible to collect the tar and ammoniacal liquor samples, and the tanks of purified gas for determining candle power and heat value, and for analysis by exact half-hour intervals. The ammonia and the naphthalene tanks sometimes ran over, and sometimes under, the half-hour; but as the exact time of starting and completing the emptying of these tanks was recorded, it was possible, by reference to the amount of gas registered by the station meter in the interval, to recalculate the results to even half-hour periods without any error other than that involved in the assumption that the constituents being tested had been evolved at a constant rate throughout their half-hour period. This might cause a slight error in the half-hour data, but could not affect the totals.

The average heating value, candle power, and chemical composition of the gas, as calculated from the figures for the nine half hours of the test, were computed by taking into account the volume of gas made during the period. Thus if in one half hour 250 cubic feet of gas of 650 B.Th.U. were produced, the product of 650 by 250 would be taken as the number of heat units produced during the period, and would be added to the figures similarly obtained for the other periods. The total number of heat units thus obtained, divided by the total output of gas, gives the average heating value. This process gives correct averages of heat value and chemical composition, but gives only an approximate average candle power, since the candle power of a gas is a function of two entirely separate variables—temperature, and the amount of free carbon liberated in the flame; and hence, in the case of a mixed gas, it will not usually be the arithmetric mean of the component gases.

The weight of gas has been computed by multiplying the corrected volume of gas by its weight per cubic foot. The latter figure was calculated from the percentage composition of the gas and the known weights of the constituents. For this purpose, the "illuminants" have been assumed to be ethylene—an assumption not strictly accurate, but involving only a slight error. These weights of the various gases as usually given are calculated for zero Centigrade. They have been recalculated to the standard conditions of 60° Fahr. and 30 inches of the barometer, with the gas saturated with moisture. The values are given in the table.

	Pounds per Cubic Foot.
Carbon dioxide	0·1140
Carbon monoxide	0·0726
Ethylene	0·0726
Hydrogen	0·0052
Methane	0·0415
Nitrogen	0·0728
Oxygen	0·0830

The weight balance is the sum of the products of distillation recovered *plus* the loss unaccounted for. The weights of coke, gas, tar, and ammoniacal liquor collected are added together, and a further addition is made of the water in the form of vapour at the outlet of the tar-separator which would condense when the gas was cooled to the standard temperature of 60° Fahr. This computation is readily made by the use of tables of vapour tension. The difference between the sum of the known products and the weight of the original charge is reported as being "loss unaccounted for."

Reliability of Results.

The preceding presentation of the methods of testing and obtaining results should be supplemented by a discussion of the means of measuring the accuracy of results so obtained.

There are several ways in which the accuracy of the work may be tested. The first is by the use of a standard coal, which should give known results. In order to check the operation of the plant in this manner, a standard Pittsburg gas coal was procured, and the first three tests, as well as one later, were made on it.

Another means of checking results is found by comparison of duplicate tests on the same coal. Exact duplication of results can hardly be expected, because of the number of variables affecting the operation; but it should sometimes be possible to partially explain divergencies as being the result of differing conditions which had been noted in the test.

Valuable internal evidence of accuracy is afforded by a study of the data gathered from a single test when viewed with the knowledge gained from other tests. The curves showing the rate of formation of gas, ammonia, and tar should bear a relation to each other, and to the retort temperature, and the curves showing candle power, heat value, and chemical composition of the gas should show some concordance.

A conclusive proof of inaccuracy is sometimes afforded by the amount of unaccounted-for loss. The sum of the products should always be less than the coal charged, for there is loss of products while the retort is open during the charging process. In our work, there is further unaccounted-for loss, because no account is taken of tar which sticks in the stand-pipe; and in our small plant there is no way of estimating the amount of water removed from the gas in the Pelouze and Audouin tar-separator nor carried past it in mechanical suspension, nor has any account been taken of the weight of hydrogen sulphide and carbon dioxide removed by the ammoniacal liquor in the scrubber and the purifier. The average amount of such unaccounted-for loss is 6·6 per cent. of the coal charged.

Each of the complete tests required over 1800 observations; and, as was to be expected, there may be found in almost every test points which are so far from their expected position that they are evidently in error. Fortunately, however, except for the initial weight of coal and the final weight of coke, the results were taken every half hour, or more frequently; so an error in any one observation exerts a relatively small effect upon the average.

It is believed that the care taken in the calibration of pyrometers, thermometers, gas-sampling tanks, and meters, has prevented any serious systematic error in the temperature measurements, or in the determination of the quantity, heat value, chemical composition, or candle power of the gas. The measurement of the quantity of tar and ammoniacal liquor from any given test is likewise believed to be fairly accurate, although the irregularities in the amount of tar from one half-hour period to the next sometimes indicate a temporary stoppage in the drips; and the possibility is suggested from results in the case of coals yielding stiff tars that the heavy tar collecting in the pipes during the latter part of the preliminary run has been washed out by the lighter tar during the first part of the regular test and has unduly swelled these samples.

There is some uncertainty concerning the yield of ammonia, as it had to be determined, as already explained, by sampling the gas at the inlet of the tar-separator. The results from the separate tests should certainly be comparable with one another; and the results on the standard Pittsburg coal, though better than customary practice, are not so high as to throw serious doubt on their reliability when it is remembered that the care taken to keep the retort in good condition and to keep the exhauster working properly should warrant higher than average results, not only in ammonia, but in all other products of distillation.

No great accuracy is claimed for the results on naphthalene, on account of the large correction factors involved in the tedious analytical process. The results should be comparable with one another; but an absolute error of 10 per cent. is probable.

It would seem that the data on coal and coke would be the least liable to inaccuracy; and yet—partly on account of the lack of sensitiveness in the scales used, partly on account of the loss in charging and drawing, or possible addition of carbon knocked off the roof of the retort in the charge, and possibly because of carelessness on account of the simplicity of the weighing operation which caused too great a reliance to be placed on a single

reading—it seems, from internal evidence, that the largest single errors are those involved in the weight of the coal and coke. The most exasperating illustration of this is found in the test on West Virginia coal, where the sum of the products is 101·7 per cent. on the weight of the coal—an error of such magnitude that it could hardly have arisen in any other way.

Another evident error is revealed in some of the tests by a comparison of the percentage of ash in the coal and coke. If the experimental tests were all correct, the calculated percentages of ash in the coke should be the same as that found experimentally, which is not the case in all the tests. The coke was carefully quartered, crushed, and sampled for analysis; but a similar procedure was not followed in the case of the coal, since it was not desirable to disturb the proportion of coarse and fine coal in the sample as it left the screen. The total amount of the charge to be sampled was so small, and the size of the material so uneven, that the accuracy of the coal samples cannot be very great. The greatest discrepancy will, of course, be noted in the ash. In the same way the composition of the few sacks of coal used for one test may vary quite materially from that of a duplicate test and from the mine inspector's sample.

RESULTS.

Eighteen tests are reported on eleven different coals from ten States. The data concerning the sources and chemical composition of all the coals and cokes are tabulated; and the course of each test, as indicated by the retort temperatures, rate of gas production, candle power, heating value, and chemical composition of the gas, rate of production of ammoniacal liquor, tar, ammonia, and naphthalene, is shown graphically for all the tests by half-hour intervals. The tables and diagram are appended to the paper; and these will be given in subsequent issues of the "JOURNAL."

The conclusions arrived at by the authors are set forth in the following

Summary.

The material here presented constitutes a progress report of results obtained in testing different coals at our experimental station for their suitability as gas coals. The conclusions are to be taken as tentative and suggestive, and not in any sense as final. Indeed, since a coal which would give good results in one works might not be satisfactory under the differing conditions prevailing at another works, a positive statement can hardly be expected from an experimental station. Its object should rather be to make tests under diverse conditions, and show which conditions are best for a given coal. The results here set forth fall far short of this ideal, because of their lack of quantity, if for no other reason. Coals should be tested at both high and low retort temperatures, and the tests should be repeated until it is fairly certain that no serious experimental error is present. The time required for such a complete study of a number of coals is so great that it has seemed wiser to present data collected on these eleven coals, with such slight interpretative discussion as is profitable, and leave the readers to draw such conclusions as they feel are warranted.

So, although the results given have been studied from various standpoints, and some interesting conclusions have suggested themselves, the only one which seems to fit all cases closely enough to warrant presentation is that which concerns the percentage yield of coke. This figure is only slightly dependent upon retort temperature, for the retort will always be hot enough to drive off the volatile matter; and the secondary changes of the distillation products at high retort temperatures will not much affect the yield of coke.

As would seem natural, the yield of coke is roughly in proportion to the ratio of the total fixed constituents to the volatile constituents of the coal. Calculating the ratio of

$$\frac{\text{Fixed Carbon } \textit{plus} \text{ Ash}}{\text{Moisture } \textit{plus} \text{ Volatile Matter}}$$

the following table is obtained. The agreement between the calculated and the actual percentages of coke is very good; the only coal not in agreement being that from New Mexico.

Source of Coal.	Ratio $\frac{\text{Fixed Carbon } \textit{plus} \text{ Ash}}{\text{Moisture } \textit{plus} \text{ Volatile Matter.}}$		Coke in Coal as Charged. Per Cent.
Wyoming	0·82	..	50·2
Michigan	1·43	..	59·5
Oak Creek, Colorado	1·53	..	60·0
Illinois	1·55	..	62·3
Tennessee	1·58	..	66·8
Pennsylvania	1·82	..	67·0
Kentucky	1·88	..	67·0
New Mexico	1·93	..	69·4
Alabama	2·04	..	68·3
West Virginia	2·21	..	73·3
Sopris, Colorado	2·90	..	74·9

It seems safe to say that the most important contribution which the experimental station has so far made has been its own development, and the proof that it can yield reliable results. The cost of equipping such a station at a gas-works is not high; and valuable results can be obtained without the large testing staff required by our efforts to collect all possible data. It would seem worth while for individual works to instal such stations to work out the problems which are peculiar to themselves.

As the results from this experiment station multiply with the years, it will be possible to draw from the accumulated data valuable generalizations which will increase the economy and the efficiency of gas-manufacturing operations.

RECONSTRUCTED CONCRETE GASHOLDER TANK

The "American Gaslight Journal" for the 23rd ult. contains an article, specially prepared by Mr. C. C. Folger, giving an account of the reconstruction of the concrete tank of the 150,000 cubic feet gasholder of the Light, Heat, and Power Department of the Municipal Council of Kingston, Ontario. The following particulars are furnished by the writer.

The original specifications were for a concrete tank, 68 feet diameter, 24 feet deep, and approximately 2 feet thick, to be composed of cement, sand, and stone, in the proportions of 1, 3, and 6; and large stones were allowed to be placed in the mixture so long as they were kept a distance of 5 inches from the inside face of the wall. The excavation for the tank was quarried out of a limestone foundation, and the wall when completed was not to be more than 4 feet above the ground. This was thought to be advisable on account of the saving effected as regards heating, depreciation, &c.

The contract for the entire masonry was placed with a local man; and upon completion the tank was found to be defective in two ways—first, on account of the enormous leakage; secondly, in respect of the irregularity of the circle, which made it impossible for the holder to work properly upon the lower T-rails—the rollers binding at different sections. This defect was remedied somewhat by cutting away the wall, and substituting smaller wheels; but the other was a serious problem. Various means were employed to stop the leaks—all kinds of loose material, such as bran, sawdust, &c., being dumped into the holder. But this process failed to check the waste. The leakage varied from 4 to 20 inches in 24 hours. The whole interior of the tank then received a coating of pitch and resin, applied as hot as possible; but this also proved a failure.

The contract was then placed with an American waterproofing concern, who proposed to line the entire interior, including the bottom, with tarred paper and asphalt. The paper was to be held against the main concrete by a brick wall which would completely encircle the tank, while the bottom was to be covered with about 4 inches of fine concrete placed over the paper after it had received a good coating of the liquid. The latter suggestion was carried out; but the building of the brick wall was suspended owing to considerable opposition regarding permeability or making it a lasting and satisfactory job. It was finally decided to call in expert advice; and Captain W. E. M'Kay, Engineer of the Boston Consolidated Gas Company, was engaged to submit a detailed report on the existing conditions and the most advisable plan of dealing with them. The conclusion arrived at was either to remove the defective walls, or contract with a waterproofing firm to align the face of the tank wall, vertically and horizontally, and apply an efficient cement waterproofing to the side wall and the bottom.

This advice was acted upon, and in the spring of last year it was decided to call for tenders for the complete reconstruction of the tank—that is, the entire concrete work was to be gone over so as to conform with the original specifications, as laid down by the Davis and Farnum Manufacturing Company, of Waltham (Mass.), who received the contract to place the steel structure in commission. The specifications were drawn up, and the contract was awarded to Messrs. Merrill and Allen, of Toronto, who carried out the undertaking successfully; the leakage being checked, and the ironwork placed in position in accordance with the original design.

The following particulars of the operations were furnished to the Council by Mr. Folger: On the 12th of July the main valves of the new holder were closed, and Messrs. Merrill and Allen commenced work. The first step was to inflate the holder with air, in order to allow the grab-hooks to be placed in proper position under the outer shell. These hooks being properly installed, the work of raising the outer lift was undertaken and carried out successfully; the shell being raised several feet above the top of the main concrete wall. The inner lift was then blown up to the water-line, and another allotment of hooks placed in position. By means of chain blocks, both were raised so as not to interfere with the proposed work on the defective concrete structure.

The concrete work consisted first in the removal of from 3 to 8 inches from the interior lining of the walls of the tank, and the lowering of the base of the tank to its proper elevation. This having been done, the *débris* was lifted clear of the tank, and deposited on the ground around it—being afterwards carted away to waste dumps. A drain was then dug all round the inside edge of the tank, to deal with leakage from the outside. This drain had a fall to a sump-hole, where proper pipe connections were made for pumping by means of a steam-pump on the surface of the ground clear of the tank, and discharging into a manhole connected with a drain. The pump was operated continuously until the concrete work was finished. On the completion of the drain, an entirely new bottom, from 4 to 5 inches thick, of a rich mixture of concrete, was spread over the whole base—being well rammed and worked into place. As soon as the bottom became sufficiently dry to walk upon, the work of placing the lining on the walls of the tank was proceeded with. The forms for this were of special design, being about 30 inches high, and a complete circle of them was coupled up, behind which was placed the mixture of concrete. This, as before, was very rich in mortar, and contained a percentage of hydrated lime; being designed to

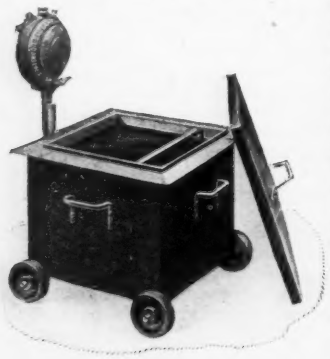
be as impervious as possible to the action of water. The work was carried out in a very successful manner; and in most places, on removing the forms, a good, clean close-grained surface was shown. The bond between the interior lining and the part of the old wall left in place seemed to be first class; every precaution being taken as this part of the work progressed. A section of the wall near the surface was removed to test the bond, and the joint appeared to be practically sealed. The lower T-rails and landing-piers were entirely removed during the course of construction; being replaced at proper intervals and in line with the upper guide-rails, so that the joints at the base of the guide-columns were decidedly improved upon.

On the completion of the concrete work, the tank was made as dry as possible, and allowed to stand for a few days before being filled with water. About the 6th of October the tank was filled up, and the work of lowering the suspended lifts was carried out successfully. The air-blast was again turned on, and the steel holder raised so that the grab-hooks might be released. Everything appeared to be going along smoothly until the wheels working in the guide-supports reached the first cross-section of the lattice girder, when the whole vessel began to bind, and a couple of rollers jammed against the T-rails. The holder was then lowered a little; and adjustments being made at the necessary columns, it was elevated a second time to the top.

On the 12th of October, gas was admitted, and the new holder brought into regular use. The first test for leakage was made from 9 a.m. on the 15th until 9 a.m. on the 16th; and it showed that the water dropped $\frac{1}{8}$ inch, or 236 gallons, in 24 hours, which was less than 10 gallons per hour. This was considerably within the guarantee; the Contractors being allowed a margin of 15 gallons per hour. Since then it has not been necessary to add any additional water in order to maintain the seal. The ironwork, as a whole, stood well the strain put upon it, and kept in good shape.

A HANDY PORTABLE TAR-BOILER.

The need has frequently been felt of a portable tar-boiler suitable for use in executing small repairs requiring a few gallons of tar, pitch, bitumen, or other compound, heated to boiling point. It has now been supplied by Messrs. A. C. Wells and Co., of Midland Road, St. Pancras, the makers of the well-known light bearing their name. The boiler, which is shown in the accompanying illustration, consists of an iron container mounted upon wheels and provided with a cover; and its capacity is 5 gallons. The tar is heated by a Wells lamp burning petroleum, and costing about $\frac{1}{4}$d. an hour; and it will easily keep the material at boiling-point. The lamp, which is entirely of iron, is readily removable, and can be used separately for lighting, if required. The boiler, which weighs only 90 lbs., can be put into a cart with the tools and other materials, and thus the expense of a separate tar-cart is saved.



ADVANTAGES OF SCREENING COKE.

This was the subject of a paper read by Mr. Guy Fortescue Gregg, the Manager of the Coke Department of the Milwaukee (Wis.) Gas Company, at the recent annual meeting of the Wisconsin Gas Association. The Company's revolving screens are 4 ft. 6 in. diameter and about 30 feet long, and are placed at an angle of 11°; the coke being elevated into a bin at the top, where it readily rolls into the screen. This is divided into three sections. The first, with openings $\frac{5}{8}$ in. by $1\frac{1}{2}$ in., with $\frac{3}{8}$-inch web, is the one through which the breeze or screenings fall; the second has openings $\frac{7}{8}$ in. by 2 in. with $\frac{1}{2}$-inch web, through which the small nut or chestnut falls; the third has openings $1\frac{1}{2}$ in. by 3 in., with $\frac{3}{4}$-inch web, through which the range or nut coke falls. The balance of the coke, which is egg size, runs out of the end of the screen into the last bin.

Mr. Gregg pointed out that there are two general advantages in screening coke. In the first place, the gross receipts from screened coke will run at least 50 c. to 75 c. per ton higher than those from pile-run coke; and the screening expenses ought not to be more than 25 c. per ton. Secondly, there are the many additional outlets for it. The egg size is screened suitable for various manufacturing purposes, such as core-ovens, &c., bakeries, and large hot-air furnaces; the nut size can be used to better advantage in hot-water furnaces, small hot-air furnaces, and kitchen ranges; while the small nut is used extensively in place of blacksmith coal for chain forges, and is also the only size that works successfully in self-feeding stoves. The breeze, mixed with soft coal screenings, can be used for boilers, as it does away with all smoke.

WATER-WORKS CONSTRUCTION ABROAD.

In the course of the Inaugural Address of the President of the new Society of Engineers (Incorporated)—Mr. Diogo A. Symons—delivered at the first ordinary meeting, held a few weeks since, he gave the following particulars of some foreign water undertakings with the designs of which he had been connected.

I will first mention an extensive scheme of water supply for a large city in Eastern Europe, the water for which it was ascertained would have to be conveyed from a source over 80 miles distant; this being the nearest spot whence a supply sufficient in quantity and efficient in quality could be obtained. After full investigation on the ground, involving the expenditure of a great deal of time and money, it was found that the water could be brought to the city by gravitation; and it then became necessary to fix upon the cheapest, and at the same time the most reliable, method of constructing the main conduit from the head works to the locality to be supplied. As a result of most careful consideration and exhaustive inquiries, it was ultimately decided that lock-bar steel pipes should be adopted—first, on account of the great saving thereby effected in weight as compared with cast iron; secondly, on account of the higher tensile qualities of this form of conduit; and, lastly, on account of the practical form of construction of the pipes themselves, coupled with the fact that the convenience of shipment was far superior to that of other pipes or tubes of similar dimensions. It will doubtless be remembered that this description of steel pipe was adopted in the construction of the Coolgardie Water-Works, Australia. The pipes varied in diameter from 31 to 18 inches; and it is interesting to note that the greatest pressure falling on the 31-inch pipe was 366 lbs. per square inch with the water flowing. The stress imposed upon the pipe material was 6·75 tons per square inch; and it will easily be realized that, though the stress could by no means be considered small, yet with steel of approved quality a sufficient factor of safety had been allowed for.

The service reservoirs, three in number, were situated at different levels, and naturally in the most advantageous positions. It was calculated that the most economical and satisfactory method of working the reservoirs was first to charge the intermediate reservoir, from which the water would flow by gravitation to the low-level reservoir; the high-level reservoir being served by means of suitable machinery operated by the flow of the water from the intermediate to the low level. It was confidently anticipated by those responsible for the design of the scheme that this method of distribution would prove far more efficacious than gravitating the water from the head works direct to the high-level reservoir. The difference of level between the intermediate and high-level reservoirs was about 170 feet; and it will be readily understood how large an increase of pressure would have been imposed on the main by gravitating direct to the high level, owing to the increased height of the hydraulic mean gradient.

The great importance of giving due and careful consideration to future requirements was much emphasized in the case of the water supply of one of the best known foreign seaside resorts, upon the inefficiency of which it was my privilege to advise. This instance was remarkable from the fact that though the head works were of excellent design, and the quantity of water (which is obtained from the chalk formation) was ample for many years to come and thoroughly efficient in quality, the system itself was designed and constructed without any regard whatever to the future requirements of the town, and, moreover, absolutely no accommodation was provided for the storage of water for use in cases of emergency. A further remarkable fact was that the service reservoirs were situated in such positions that in many instances the pressure was insufficient to force the water above the second floor of the important buildings in the town. Fortunately the supply is ample; but it is not difficult to realize what disastrous results would without doubt be occasioned in the event of accident or damage to the main supply conduit to the reservoirs. I may mention that the scheme was not designed by an English engineer. It was found necessary to entirely re-design it, involving the expenditure of several thousands of pounds, in order to make the supply efficient.

At a special meeting of the Leamington Town Council held on Monday last week, a resolution was submitted confirming a recommendation of the General Purposes Committee that the freedom of the borough be conferred on Alderman Sidney Flavel. Mr. G. Norris, in moving the resolution, said Alderman Flavel had worked for the public of Leamington for 35 years. He had been Mayor six times, and was now the senior member of the Council and Chairman of the General Purposes Committee. He was also senior Justice of the Peace for the borough, and a Magistrate for the county. He had been a member of the County Council many years, and had done good work on that body. It may be remembered that Alderman Flavel was present at the dinner given to the members of the Midland Association of Gas Managers by the Leamington Gas Company, on the occasion of their visit to the town in May, 1905; and that subsequently he entertained them at tea in the Imperial Foundry of the Flavel Range and Gas-Stove Company.

ASSOCIATION OF WATER ENGINEERS.

Abridgments of Papers and Discussions.

We continue to-day our report of the meeting of the Association, with the following extracts from the two last papers and discussions.

PERMANENCY OF OVERFLOW SPRINGS.

By Henry Preston, F.G.S., of Grantham.

Stretching through the County of Lincolnshire in an almost unbroken line from the Humber in the north to Grantham in the south, is a range of hills known as the "Cliff," consisting of an escarpment of Oolitic limestones overlying Lias clay; the scarp slope facing west owing to the easterly dip of the strata. The scarp slope of the cliff shows several interesting phenomena relating to springs, particularly in regard to those usually known as "overflow springs."

In 1903, the author referred to one of these in a short paper read before the Geological Society, and showed by means of certain sections what appeared to be the cause of the permanency of a small spring which flowed in an opposite direction to the usual dip of the strata. Since that time other examples have been noted by him, of permanent springs flowing against the dip, and two of these he now proposes to describe. Also he proposes to describe an example of a spring being found when excavating in dense clay, because the explanation which he offers of the origin of this spring helps to throw light on the origin of one at least of the other two.

In 1907, the Grantham Water Company purchased a piece of land lying south of their pumping-station at Saltersford, for the purpose of constructing a storage reservoir. The land formed part of the river valley, and was locally known as the "Swamp." Several springs flowed into the Swamp from the east, and though they were all of the character of overflow springs, yet one spring at least has been permanent in character, even during the remarkably dry seasons of the last twelve or fifteen years. To increase the width of the reservoir, it became necessary to cut away the foot of the hill to the east of the Swamp for a distance of about 160 yards. The ordinary superposition of strata here is: (3) Lincolnshire limestone, (2) Northampton sands (ironstone), (1) Upper Lias clay; and the junction planes were expected to be practically level. It was soon found, however, that the surface of the Upper Lias formed quite an irregular line. In one place a perfectly V-shaped valley, 40 feet wide, had been eroded in the clay, and the cavity filled with ironstone, which appears to have steadily followed the erosion of the gap. But the most important variation in the line of section occurred just where a quarry was made. Here a valley 140 feet wide had been carved into the clay to a depth of 14 feet. It is perhaps impossible to say definitely how the valley originated; but the bottom had a decided inclination to the west, and the whole space was filled by a thick tongue of boulder clay. This tongue has then been buried by land creep, and preserved in this manner from ordinary denudation. The character of the boulder clay was somewhat unusual, inasmuch as it consisted largely of huge limestone blocks—"strangers" to the district—weighing from 1 to 10 tons each. It was at this point that the permanent spring occurred which fed the Swamp; and the excavation showed that beneath the surface a mass of coarse boulder clay, lying on a westerly inclined surface, had formed a hidden drainage valley, which collected water from a limited watershed, and had given rise to a permanent spring flowing in an opposite direction to the normal dip.

On the west side of the river at Saltersford, where, as has been explained, the strata all dip towards the river, it became necessary a few years ago (in 1906) to construct a covered reservoir so as to store filtered water. Generally, the Upper Lias clay in which the excavation was made is a dense, uniform blue clay, and is very suitable for purposes such as that named. Knowing that trouble had been experienced by building reservoirs in clay beds having a strongly defined dip, we had taken precautions against penetrating into the hill, and built on a level piece of ground by the side of the river. Our excavation, after passing the soil and alluvium, entered the clay to about 11 feet, and all went well until one morning when we noticed a mass of clay which had slid from its position leaving a slickensided surface, the strike of which was roughly in a north and south direction parallel to the river. After this, the sectional face of the clay was carefully examined and a number of fold lines were discovered which were only revealed by a slight stain of iron-oxide. Before the bottom of the excavation was reached, some of these folds were found to contain water under pressure; and it ultimately became necessary to carry the springs to the outside of the reservoir walls, and to keep the pressure down by pumping until the floor had been put in, and had become strong enough to resist the pressure.

The second case of overflow spring occurs on the scarp slope of the "Cliff" at Leadenham, about 11 miles south of Lincoln. The water supply for the village is taken from a number of small springs, which rise immediately under the brow of the hill; and although the yield varies according to the season, the supply is generally sufficient for the village, showing again permanent springs issuing in a direction opposite to the normal dip of the strata. Quite recently a section has been cut at the top of the hill to test the thickness and quality of the ironstone (Northampton sands) which here overlies Upper Lias clay. This cutting has extended 76 yards from the brow of the hill in an easterly direction; and it was found that the beds overlying the Upper Lias were dipping towards the west for the whole length of the section—the amount being 5 feet in the total length. At the top of the ironstone, two bands of very tough and dark-coloured clay occur, separated by a thin bed of sand; and these showed a series of corrugations having steep faces to the east, and gentle slopes to the west. These corrugations are sections of natural gutters running in a northerly direction.

The principal springs which supply the village occur about 400 yards north of this section; and the ground having a slight northerly dip, the area of supply lies to the east and south of the springs. It would also appear that their permanency is materially increased in consequence of the folds in the clay bands catching the drainage, and diverting it northwards towards the springs. In this way the water is prevented from seeping out at the brow of the hill.

The westerly dip of the strata is probably due to two causes—firstly, to the erosive action of water issuing as overflow springs at the hill-brow, whereby the upper surface of clay and the lower surface of limestone would be gradually wasted away; and, secondly, by the great scarp face of Lias clay (over 100 feet deep) being gradually forced out by the superincumbent weight of rocks above. Both actions have had the effect of lowering the limestones and giving them a new direction of dip. The corrugations in the clay bands seem to show that this latter action has been the most important.

Briefly then, the permanency of the Leadenham overflow springs is due primarily to alteration of dip caused by erosion of the junction planes lowering the water-bearing rocks; and it is greatly assisted by the ridges and furrows in the thin clay bands holding up the water, and allowing it to drain more slowly to the spring outlets.

In conclusion, the author desires to point out that underground erosion has often had extensive influence on the local dip of strata; that the phenomenon of "creep" is much more common than is sometimes supposed; and that river valleys which cut across various kinds of strata have the effect of relieving pressure at one point, and bringing it into action at another, so as to cause distortions of stratified rocks, which at times are very puzzling. The small examples here noted are but an indication of what we may expect upon a larger scale under other circumstances. The rocks of the earth's crust are very susceptible to change by pressure, and the slow action of denudation and erosion, whether subaerial or subterranean, is continuously effecting changes in the lie of rocks, which may, and often do, affect the underground water supply.

Discussion.

Mr. W. Whitaker, F.R.S., F.G.S. (Croydon), prefaced his remarks by, on a question of terminology, laying a formal protest against the use of the term "overflow spring." To him "overflow" and "spring" meant the same thing. But he understood there was some good reason for wanting to differentiate between these springs and springs flowing down long slopes. He (Mr. Whitaker) preferred calling them scarp springs. At some length, the speaker explained, in supplement to Mr. Preston's information, the geological changes that gave rise to springs of this kind. It was interesting, he said, to note how local geological changes would have important practical change; and one had to be careful whatever work was being done, because slips would happen, and where they had once happened might happen again.

Dr. Herbert Lapworth (Derwent Valley Water-Works) said, to his mind, the paper was particularly interesting, because it happened to be on a subject of great importance to engineers in the matter of land creep. In this particular district, as Mr. Preston had explained, and he thought quite rightly, this movement of the scarp to such a large extent was due to underground solution. He believed they would hardly find a case where they had sidelong ground sloping towards a river where they did not get movement of this sort—where they had beds normally dipping away from a valley being dipped over from the surface towards the river. In North Derbyshire (in connection with the Derwent Valley works), in the shales where they cut their trenches through sidelong ground, they found this phenomenon. In his section of aqueduct, there were something like seven or eight miles of pipe-trench; and he found the phenomena wherever the trench entered sidelong ground. This was a subject of great importance to engineers. Where a trench was cut, the pressure was relieved; and the tendency for the ground to slip down into the trench in such cases had been very serious. There was an instance in a large water scheme, some years ago, of a line of syphon pipes being carried down hill by this creeping movement. Some time since, when he was working out the dam sites in a valley he found there were trial boreholes sunk for some distance down—20 to 25 feet deep—close to where he found the beds out of place. On the top there was a little slip down the hill; but lower down things were in their normal place. He asked Mr. Preston whether he found the limestone much fractured, and the cracks filled in with material; and whether he had gone into the question of the yield of these springs in relation to the area of reverse dip.

Mr. F. W. Hodson (Loughborough) thanked Mr. Preston for putting in such clear language the reasons for these scarp springs. He had recently been interested in the water supply of Horncastle, which was entirely supplied from scarp springs in the chalk; and one of Mr. Preston's illustrations almost entirely met the case he

had worked out there. At the same time, he did not think the explanation would be entirely applicable to all scarp springs.

Mr. PRESTON, in reply, said he was obliged to Mr. Whitaker for what he had said in enlarging on the purport of the paper, and in further explaining the origin of the scarp springs, which was undoubtedly a finer name than overflow springs. The word "overflow," however, appealed to him, inasmuch as they flowed out after the land had been pulled in the opposite direction to the ordinary travel of the water. Then Dr. Lapworth asked about the yield of the springs. In the cases he (Mr. Preston) had noted, the yield was comparatively small—one did not yield more than 18,000 to 20,000 gallons per day. But the one at Leadenham yielded more than this; it was quite double the strength in the summer time at its lowest yield. The limestone that had crept down the hill over the boulder clay was undoubtedly fractured a lot. It seemed to have tumbled down, and become fractured and more pervious to water, and the fissures had taken a westerly direction, looking as though it was an ordinary dip of the strata. Respecting Mr. Hodson's remarks, he believed that at Horncastle he had a longer area to deal with in regard to the dip than he (Mr. Preston) had at Leadenham; and his explanation was very interesting.

NOTES ON THE COLOUR OF WATERS.*

By AD. KEMNA, D.Sc., of Antwerp.

From the hygienic point of view, which is undoubtedly the most important, the colour of a water is in theory only a subordinate question. In practice, however, it is quite the reverse. People go by the most apparent characters; and a discoloured water always raises suspicion, which is, after all, legitimate.

First of all, what is the colour of pure water? All our text-books reply none at all. Pure water was for years declared to be absolutely colourless; but natural waters present us with a variety of hues and shades. At last, Bunsen had a novel idea. Having prepared some distilled water, he poured it into a long tube; and looking through the tube, he found the water had a blue colour. This being proved, it then follows that any other colour indicates an alteration of the original degree of purity. Tyndall's work on the blue of the sky as due to polarization was also applied to water. The theory of colloidal solutions is a new departure in physico-chemistry and certainly has a bearing on the question of the colour of water. These so-called "solutions" are really suspended solid matter. The suspended particles are of extremely minute size. Quite recently it has been contended that the so-called peaty acids are not solutions at all, because of their non-conductivity for electricity, which is characteristic of colloids, whereas all salts really dissolved are electrolytes and good conductors. Their extremely small size keeps the dispersed particles in suspension; but there are means of increasing their size by aggregation, till they get heavy enough to precipitate. To use the language of the engineer, this means simply clarification through settling. This we have been doing for years past; and, on the whole, with some success.

All this goes to show that there is no lack of scientific interest in the question of the colour of water. This paper is, however, devoted to the more practical side of the question, in which theoretical considerations may be largely dispensed with. When watching the gravel strainers at work at the Waelhem pumping-station, the author's attention was called by his assistants to the fact that sometimes after the first passage there was an increase of colour; the effluent water being yellower than the inlet water. The difference was not much, but still appreciable. This result seemed strange. The tubes containing the water were special tubes for nesslerizing (Wanklyn's chemical test for free and albuminoid ammonia). Having flat bottoms, they were placed in a rack and rested on two wires. It was noticed that these wires were better seen, and more clearly defined, through the effluent water than through the inlet water. In tubes with round bottoms, and if they had been standing on a glass plate or on a wooden tray with holes, this difference would very likely have escaped notice. The result showed that, after passing through the strainers, the water was more yellow and more clear, more coloured, but more transparent or less turbid. The gravel strainer has, therefore, done its duty by taking out something; and this something was evidently matter in suspension, as the turbidity was reduced. But this clever reasoning ends in a truism, as the very reason for the introduction of strainers is the removal of suspended matter. The real problem is not there; but in the logical connection between the reduction of turbidity and the increase of colour.

To observe the colour of a water seems simple enough; but the foregoing proves that, after all, it may be more complicated than we expect. The first question that arises is the length of the tube. That a greater length will give a deeper colour is quite obvious, and is borne out by fact. The 2-feet tube was formerly in constant use by water engineers, as it was generally admitted that the colour of water afforded a valuable guide as to its condition. On the other hand, it was a mistake to rely upon this alone, although a pardonable mistake when there was no other test available. Now that bacterial analyses have come into general use, the tube has been somewhat neglected, which is also a mistake.

The next question is whether the tube should be of glass or metal. This seems at first sight of no consequence; but, in fact, it involves the obviously important question of side illumination or no side illumination. Glass being transparent, light can enter the tube, not through the bottom only, but also through the sides at every level; so that we work, not only with transmitted light, which has passed the whole thickness of the water, but also with a certain amount of light which has come into the water sideways, and which has passed through a part only of the layer of water. Now the quantity of such "side light" depends upon the presence of something which can arrest the side ray, and reflect it axially towards the eye—*i.e.*, it depends upon the turbidity of the water. The intensity of colour depends upon the thickness of the layer of water; but the rays reflected by the solids suspended in the upper strata will scarcely suffer any alteration, and will appear nearly white. This admixture of white light, of course, makes the water look less yellow; and as the amount of reflected light is proportional to the number of reflecting particles, the more turbid water will not appear such a deep yellow as it really is, and the less turbid water will better show its natural yellow tinge. This explains the deeper colour of the filtered effluent.

Now as to some further consequences. If the side light really diminishes the colour of a water, the exclusion of such side light must increase the colour. Wrapping the glass tube in black cloth or paper does increase the colour, and to an unexpected degree. Two samples of the same water, in identical tubes, the one naked, the other covered, differ so much that it is difficult to believe that they are really the same. There also the difference of colour is proportional to the amount of the suspended (reflecting) matter, diminishing after each passage through successive compartments of the gravel strainers, and being almost imperceptible after final sand filtration.

Another very simple experiment consists in excluding transmitted light, and working with reflected light alone. This is easily done by shutting the lower end of the glass tube with a short cup of black cardboard. If, now, there are no suspended particles, there cannot be any reflected light—in fact, pure distilled water looks as black as ink; while the greater the turbidity, the more light is visible. This light is to a great extent unaffected by the real colour of the liquid. The raw water shows a white bluish opalescence, only slightly tinged with yellow; the luminosity gradually decreasing at each stage of straining. Another way of excluding transmitted light is by looking through the tube from the side, so as to catch the reflected part of the axial rays. The results are the same as with the other method; but a very strong light is wanted, so that for practical purposes and daily use the first method is the best.

Following a reference to Dr. Tyndall's experiments at the Royal Institution, he said: The members who went to Paris in 1906 will remember an interesting example of colour in water. Two of the sources of supply from the south of Paris, the Vanne and the Loing and Lunain are discharged into the Montsouris reservoir. A handsome building contains two tanks lined with white porcelain tiles, against which the beautiful blue colour of the water is very conspicuous. Part of the surface, however, in each tank shows a slightly greenish tinge, which at first is difficult to account for. The explanation lies in the fact that the handsomely decorated ceiling above each tank bears the name of the source on a scroll, having a yellow background; and it is the reflection of this yellow on the surface of the water which, combining with the pure blue of the water itself, produces the green tinge. This is an excellent instance of the sensitiveness of water to colour.

Discussion.

The PRESIDENT (Mr. W. H. Humphreys) said it was with deep regret that they heard the author of the paper was at the last moment prevented from attending the conference. Dr. Kemna was one of the most eminent scientists in Northern Europe. Those who had had the privilege of knowing something of his great work in connection with water supply would appreciate his difficulties, and admire the skill and ability with which he had overcome them. He had alluded to Dr. Tyndall's beautiful experiment before the Royal Institution. Dr. Kemna's own experiments and methods of showing the colour in water were quite remarkable, and brought the subject up to date. When Professor Tyndall carried out the experiment referred to, he drew attention to the fact that distilled water in an ordinary drinking glass exhibited no trace of colour, but he arranged an experiment which gave sufficient depth of distilled water so that it produced a very decided colour. He took a tube 15 feet long, fixed on plate glass ends, and laid it horizontally on supports. He placed at one end of the tube an electric lamp for the purpose of sending light through. The tube was half filled with freshly distilled water, which cut the tube in two equal parts horizontally—half of the light going through air, and half through water. At the other end of the tube, he fixed a lens, which projected the light which had passed through the tube on to a screen. By this means, he magnified an image composed of two semi-circles—one formed by the light passing through the water, and the other by the light passing through the air. Placed side by side, it was at once seen that the air semi-circle was pure white, and the water semi-circle bright and delicate blue-green. His experiment was to prove that, by augmenting the thickness through which the light had to pass, it deepened the colour—proving that the destruction of the light rays took place within the absorbing body, and was not an effective surface merely. The researches of Tyndall and Kemna provided them with both cause and effect;

* In the author's absence, the paper was read by Mr. Easton Devonshire, Assoc.M.Inst.C.E., Chairman of the Antwerp Water-Works Company.

and, so far as they were able to go into the subject in the absence of the author, the colour tubes exhibited in the room would enable the members to judge as to some of the effects. The colouring matter found in their local waters arose mainly from peat and vegetable matter, and was considered by scientific men to be harmless. The colour was reduced by exposure to the light. For the purpose of noting the effect of light on a slow-flowing river, he had taken samples of the water on the same day from the same river, and at varying distances; and he had found that the higher they got up the river, there was an appreciable increase in colour. For the purpose of testing the colour of water, there was in use at the York Water-Works an apparatus known as the United States Geological Survey apparatus. In outline, the method consisted of the selection of a standard glass colour disc, whose depth of colour was the same as that of a 200 mm. column of the water to be tested. It consisted of four aluminium tubes with water-tight glass ends. Two of these were 200 mm. long; one, 100 mm.; and one, 50 mm. One of the long tubes was fitted with a small spring clip, so that it could hold one or more of the standard glass colour discs, of which there were six furnished with each set. These discs were of various degrees of colour, and were mounted in aluminium rings. Each disc was carefully rated or calibrated, and was stamped with a number corresponding to its value in the platinum-cobalt scale. If the water to be tested was of moderate colour, it could be poured into the 200 mm. tube. This should be rinsed out once or twice. The 200 mm. standard holder could then be fitted with one or more colour discs until the eye could detect no difference between the colour of the water and that of the disc, when both were held about 8 or 9 inches from the eye, and in the direction of a clean white background—such as a piece of white paper or tile, brightly illuminated by daylight. If the day was somewhat cloudy, the tube could be pointed towards the sky. Good results could not be obtained by artificial light. Each colour disc carried two numbers—one of which was less than 100, and represented the colour value; the other was over 100, and was merely the serial number. If it was necessary to use two colour discs together, the sum of the two colour numbers represented the colour value. If the water was rather highly coloured, it could be tested in the 100 mm. tube; but in this case the colour values on the discs must be multiplied by two; if the water was very highly coloured, the 50 mm. tube must be used, and the readings multiplied by 4.

Dr. SAMUEL RIDEAL said that Dr. Kemna was wise in bringing this subject before the members at the present time. It was a matter that concerned the consumer, because they had to supply a water that would satisfy not only the consumer's nose, but his eye. If there was any objectionable colour as it appeared in a tumbler, it was their (the engineer's and the chemist's) duty to find out the cause, and how to prevent it. Alluding to the experiments of Tyndall and Bunsen, he reminded those present of the lecture experiments of Dr. Edward Frankland. In these, long opaque pipes were used, so that there was no transmitted or side light. These tubes passed round the room, with reflectors at different distances. As the length of water increased, a deeper blue colour was obtained. Therefore, if they had a long enough tube, they could say there was no colour at all in the water; but, as a matter of fact, when one had a colourless water, it meant that they had all sorts of colour in it. They had to consider how much of the different kinds of colour passed through the water. This involved measuring the amounts of the different kinds of colour passing through different lengths of water. The American tubes referred to by the President were a modification of Lovibond's tintometer, which had been used for water colour in this country. He had worked with it; and the most extensive set of records made with this instrument were those of Mr. Parry of the Liverpool water at Vyrnwy. The speaker then gave an account of some of his own work on the subject, when employing Lovibond's tintometer. In his concluding remarks, he said it would seem from the Antwerp results that Dr. Kemna had filtered his water too much to give a satisfactory supply. If he did not take out all the suspended matter, the water would not look so yellow, and consumers would be better pleased with it.

Mr. J. J. LACKLAND (St. Helens) said, in relation to the colour of softened water, they had observed for some years, after lime had been added to the water and filtered out in the usual way, that the softened water had a beautiful blue colour; but, when the water was in this condition, it had the peculiarity of depositing lime in the pipes. The water was first passed out of the filters, and stored in the service reservoir, in which, in the course of twelve months, it deposited several inches of white mud, and then again in the mains, and periodical flushing had to take place, which gave something like whitewash after the course of weeks. In order to stop this objectionable feature, they adopted the device of blowing in, by a steam jet, carbonic acid from burning coke on the water passing from the filters to the reservoirs. This had the effect of removing the colour from the water; and after it passed from the reservoir, they could see a pin through 16 feet of water. But the peculiarity was that, instead of blue, there was a suspicion of green—possibly due to the rust from the coke.

Mr. W. M. LANGFORD spoke of the usefulness of the tintometer in making comparisons between the raw and the supplied water, and alluded to an occasion when, by its aid, detection was made of pollution in filtered water arising from leakage in the sides of the filter. By the bacterial method, through the period of incubation, this would not be detected for several days; but, as it was, they were able to put the filtered water out of use at once.

Mr. WILLIAM WHITAKER, F.R.S., F.G.S. (Croydon), said this question of the colour of water was being taken up by Lord Rayleigh. Only the previous week, he (Mr. Whitaker) came across an account of a research of his on the colour of water and air. He read it; and it disagreed with his feelings a little, so that he came to a conclusion a little adverse to Lord Rayleigh. He thought that eminent physicist might be a trifle colour-blind. Care must be taken that experimenters were not colour-blind in any way; but the curious thing was that so many people were. Lord Rayleigh had come to the conclusion that the prevalent colour of water was green; but he (Mr. Whitaker) could not say that it appeared so to him.

Mr. EASTON DEVONSHIRE explained the differences between the apparatus brought before the members by the President and that introduced to them in Dr. Kemna's paper. Incidentally, he mentioned that the natural colour of river water was apple-green. At the time of the visit of the Association to Paris, some of the members would remember a rather curious effect that the ozone process had in practically bleaching the water after it had, to all intents and purposes, been freed from turbidity. The water was perfectly transparent in a considerable length—he thought it was 4 metres—of tube. It was transparent; and the apple-green, after treatment by ozone, changed to an intense or pure blue.

[Dr. Kemna will reply to the discussion through the "Transactions," after reading the official report.]

The discussion on the paper presented by Mr. E. Young Harrison on "The Wellingborough Water-Works and Softening Plant" was postponed until the winter meeting; and we defer publication of extracts from it till the discussion takes place.

REGISTER OF PATENTS.

Producing Gas and Coke.

GOBBE, E., of Jumet, Belgium.

No. 11,265; May 12, 1909. Date claimed under International Convention, May 16, 1908.

This invention consists (in the words of the patentee) in a continuous process and apparatus; being characterized in that a portion of the comparatively cool gases produced in a single vertical oven is repassed therethrough in such quantities as to cool the red-hot coke and transfer the heat from the coke to the distillation zone to continue the distillation. In order to effect this transfer thoroughly, the gas must circulate slowly, so that the greater part of the cool gas may have time to pass actually into the interior of the lumps of coke which are sufficiently spongy to permit of this. If, on the other hand, the gas should circulate too rapidly, the gas would reach the distillation zone (the zone in which distillation of the coal actually takes place) in too cold a state, the effect of which would be speedily to cool the apparatus and bring the reactions to an end.

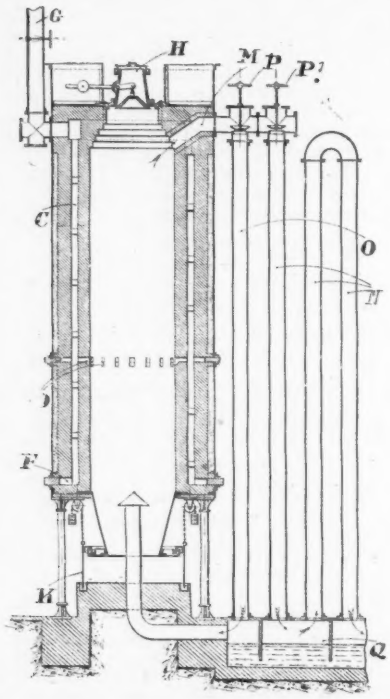
The process is to be distinguished from the operation of that type of intermittently acting gas-retort in which part of the gas obtained in one charge is cooled and separated from all bye-products, and, when the next charge is being distilled, is utilized to cool and scour through the space which exists between the bottom of the retort and the part which is not sufficiently heated to effect proper distillation of the material to be coked, in order to prevent an accumulation of the gaseous distillation products in the empty spaces between the filling material. It is necessary to provide the usual external heating jacket in continuous operation in connection with the retort; "so that it must not be assumed that the recuperation of heat from the red-hot coke, which plays so important a part in the economical aspect of the present invention, comes into operation. But it may be surmised that the quantities in which the gases are passed through the retort, in order to scour effectively the space above referred to, are such as to cause the gas to reach the distillation zone at a comparatively low temperature, which would result in the rapid cooling of the retort were no continuous heat supplying means provided." Not only are the gas and the coke produced continuously, but the flow of gas is so regulated that it enters the reaction zone at a temperature almost equal to that of the red-hot coke through which it has just passed; so that, were it possible to avoid all heat losses through the walls of the apparatus, &c., no external heating means would be required. In practice, however, it is usually necessary, in order to compensate for unavoidable heat losses, either to burn continuously a small quantity of gas in a jacket surrounding the distillation chamber, or to consume part of the coke for a short period of time. As, however, only a relatively small amount of heat is required, the fuel expenditure is practically at a minimum.

The inner jacket (p. 876) is separated from the outer jacket by a space C, in which gas supplied from the apparatus through small holes D can be burnt. The air enters at the base of this annular space through openings F, which can be closed as desired. The combustion which takes place in the space C heats the walls of the apparatus to prevent losses of heat therethrough; and the products of combustion escape comparatively cool at G. The coal is introduced through a hopper H. The ash-pit is formed by a circular apron K, the edges of which enter water-seals.

The illuminating gas issues at the top of the apparatus through the opening M; part of it being directed towards the scrubbers and the gasholder or bell in passing through the conduits N, while the other part returns to the base of the apparatus in passing through the conduit O. The tar which condenses in the conduit and the condenser constituted by the conduits N is collected in a tank Q.

The operation of the apparatus is as follows: When the apparatus contains well-kindled fuel and the charge proper has been introduced,

the ash-pit and the hopper are closed. The registers P and P^1 are then opened, so that a part of the comparatively cool gas leaving the apparatus descends towards the ash-pit through the conduit O; while the other part proceeds directly into the conduits N, the scrubbers, and the gas bell. The cooled gas which reaches the ash-pit absorbs the heat stored in the coke which is at the base of the apparatus, and cools it in transferring its heat units upwards into the reaction zone, where some of the heavy hydrocarbons lose a portion of their carbon, thereby forming, by dissociation, new gaseous compounds. The mixture of return gas and gas produced passes through the layer of cool coal with which the apparatus is regularly charged from above, and heats this coal before escaping in a comparatively cooled state through the discharge conduit M.



Gobbe's Gas and Coke Producer.

Cooling of the apparatus is avoided by constantly burning a small quantity of gas in the space C of the jacket, or by allowing air to enter through the ash-pit every time it is opened for withdrawing a certain quantity of cool coke. Assuming that it is necessary to open the ash-pit every hour in order to extract cool coke, and assuming that this operation occupies a few minutes only, during this time the air will burn a small portion of the coke in the reaction zone, which will reheat the distillation zone. During this period, carbonic oxide gas is produced, and is burnt in the space C by opening the chimney G and the air-holes F when the ash-pit is opened. The coke burnt during this period of internal reheating, and also the gas that is allowed to burn in the jacket of the apparatus, cannot amount to any considerable expenditure of fuel, because the apparatus produces comparatively cool gas and coke. It only loses heat through its walls, which can, however, be made very thick. "It therefore realizes the conditions which must be obtained for distilling coal with a minimum amount of fuel for combustion."

Bye-Pass for Gas-Meters.

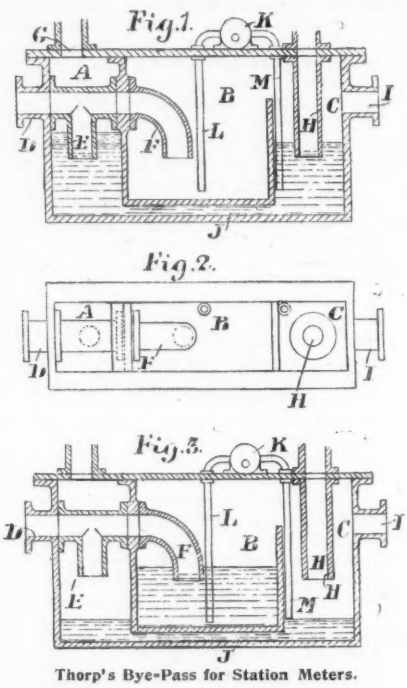
THORP, T., of Whitefield, near Manchester.

No. 12,090; May 22, 1909.

This invention relates to the conducting of gases alternately either through a meter or other apparatus or line of piping (or past the same) direct from the supply to the delivery pipes, and consists in an improved arrangement of bye-pass with liquid seals for this purpose. It is more particularly intended for use with station meters of the rotary fan-wheel type.

In bye-pass arrangements with liquid seals hitherto proposed, three pairs of compartments were arranged, one of which would be filled while two were emptied, and *vice versâ*, for conducting the gas either in one or the other way; the emptying and filling being done through three-way or other cocks. This arrangement depended for its satisfactory working on the attention of the operator in manipulating the several cocks, as if one set of compartments were filled before the other set were emptied, complete stoppage of the gas would result, and the lights (for instance) supplied by the delivery pipe would be extinguished. Also undue pressure in the supply pipe would be set up in many cases—for instance, if the supply were forced to a station meter by an exhauster. On the other hand, if the cocks were not turned off as soon as a set of compartments was emptied, gas would be passed into the drain pipes. These risks are obviated by effecting the change of way by transferring the liquid from the compartments to be emptied to those to be filled, by means of a pump, and regulating the volume of water contained therein, so that the way to be opened is always opened before the other way is closed.

Fig. 1 is a sectional elevation of the bye-pass, with the liquid in the position for passing the gas direct from the supply to the delivery pipe. Fig. 2 is a plan with the cover removed. Fig. 3 is similar to fig. 1, with the liquid in the position for passing the gas through the meter or other pipe line.



Thorp's Bye-Pass for Station Meters.

The bye-pass consists of a closed chamber or cistern divided by two vertical partition walls into three compartments A B C. One partition plate extends to the cover and is gas-tight with it, while the other one stops short at some distance from the top, or has openings in it, so that the compartments B C are in communication with each other at the top. The gas-supply pipe passes gas-tight through the compartment A, where it has a downward branch, and into the compartment B, where it is bent downwards. A branch D is cast on the end of the cistern, to which the supply pipe is connected. A tee-pipe is fixed between the end of the cistern and the left-hand partition, having a downward branch or dip-pipe E; and an elbow dip-pipe F is fixed to the other end of the partition. The compartment A has an outlet to which is connected the pipe leading to the measuring chamber of the meter or pipe line to be disconnected and connected—for instance, an outlet G at the top, or at the side. The delivery pipe from the meter is connected to a pipe H depending into the compartment C, either to a straight pipe (as shown) or an elbow pipe, as may be most convenient. The gas delivery pipe to the main is connected to the compartment C, either through a branch I, at the end as shown, or at the side near to the top of the cistern. The compartments A C are in communication with each other at the bottom through a passage J cast in the cistern or through other pipe connections.

If the middle compartment B is filled with liquid to such a height that the downwardly directed end of the gas-supply pipe is sealed to the depth corresponding to the gas pressure, while the first and third compartments A C are empty except for the quantity of liquid required to seal the passage J (as in fig. 3), the gas will pass through the downward branch of the supply pipe into the compartment A, and through the pipe G to the meter; then through same, and through the down pipe H into the compartment C, and on to the outlet I. If the liquid is now emptied out of the middle compartment B into the end compartments A C (as shown in fig. 1) so as to seal the dip pipes in them, the gas will pass through the end of the pipe F into the compartment B and over the right-hand partition into the compartment C, and to the outlet I, without passing through the meter or other pipe line.

The transfer of the liquid from the middle to the end compartments and *vice versâ* is effected by a pump actuated, when required, by hand or power. Preferably a rotary pump K, with sliding vanes, adapted to be rotated in either direction without any valves being required, is used. One pipe branch of the pump is connected to the pipe L, depending into the compartment B, and the other to the pipe M, depending into the compartment C. The latter stops short at such a distance from the bottom that sufficient liquid is left in the meter compartments to seal the passage J.

Conveyors for Hot Coke.

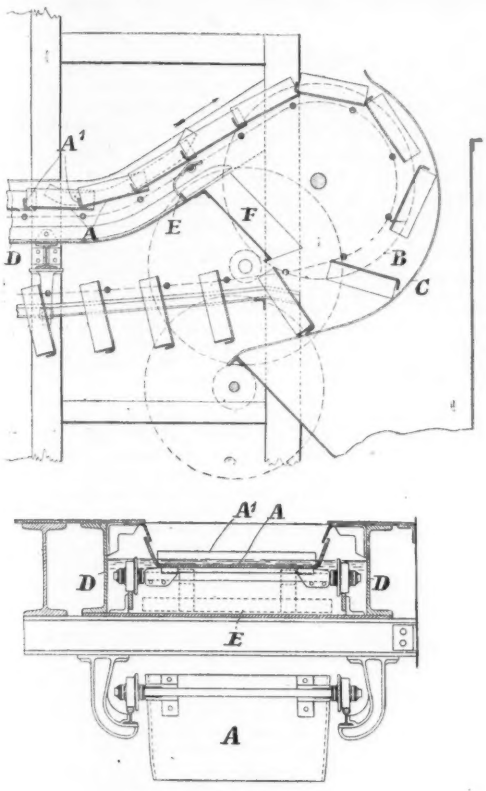
BABCOCK AND WILCOX, LIMITED, and PATON, P., of Farringdon Street, E.C.

No. 12,313; May 25, 1909.

This is a "Patent of Addition" to No. 15,582 of 1906; and it has for its primary object to render conveyors of the kind then described better adapted for handling hot coke.

As shown, the conveyor comprises (as described in the 1906 patent) a series of trays A carried on two endless chains, and adapted to be tipped as they pass over the end drum B in contact with the end guides C; the trays being each formed with side flanges and with a lip A_1 at one end, so that in their movement in the direction of the arrow they have a positive action in taking with them the coke as it is discharged from the retorts.

A trough D, composed of side and bottom plates (made water-tight),



Paton's Hot-Coke Conveyor.

is filted in the line of travel of the trays, and filled with water to any depth required, so that the bottom of each tray, as it passes through the trough, may be submerged in order to keep the trays and chain cool when in contact with the hot coke, and, if desired, to partly quench the lower strata of coke. In addition, automatic sprinklers at intervals would quench the coke in the usual way.

Rakes E are attached to the conveyor chains to drag any sediment deposited in the trough bottom towards the delivery end, where it is discharged down a shoot F along with the main coke discharge.

Fuel for Gas-Fires.

FOUCAR, J. L., of St. John's Park, Blackheath, S.E.

No. 12,785; June 1, 1909.

This fuel for gas-fires consists, broadly, of fused silica in the place of the ordinary fire-clay balls or other substances (such as asbestos) which are heated by the burners and radiate heat into the room. The silica is first fused, and blocks or pieces of any convenient form and size are arranged so that they are heated by the burners.

Fused silica, the patentee remarks, presents considerable advantages as a fuel for gas-fires. In the first place, it is more durable than fire-clay, and is dustless. A frequent cause of trouble with gas-fires using fire-clay balls is the partial choking of the burner holes with dust or particles of fire-clay; but this objection "is removed with the silica fuel forming the subject of this invention." He has further found that fused silica fuel possesses high radiating power.

Manufacture of Ferric Oxide.

GILL, J., of Pendleton, Lancs.

No. 21,884; Sept. 25, 1909.

In an earlier application (No. 5618 of 1909), the patentee described a process of preparing ferric hydrate $Fe_2(OH)_6$ and ferric oxide Fe_2O_3 by treating ferrous chloride $FeCl_2$ with calcium carbonate $CaCO_3$ at a temperature of about 180° Fahr., and forcing carbon dioxide and air through the mixture, while maintained at a considerable pressure above normal. He now finds that, by increasing the temperature of the mixture of ferrous chloride and calcium carbonate or bi-carbonate during the oxidation process to about 200° to 220° Fahr., magnetic oxide, Fe_3O_4, is formed. The product is washed to free it from soluble salts, and is then filtered and calcined.

$$CaCO_3 + H_2O + CO_2 = Ca(HCO_3)_2.$$
$$FeCL_2 + Ca(HCO_3)_2 = FeCO_3 + CaCl_2 + H_2O + CO_2.$$
$$3\,FeCO_3 + O = Fe_3O_4 + 3\,CO_2.$$
$$2\,Fe_3O_4 + O\ (\text{calcined}) = 3\,Fe_2O_3.$$

By this improvement in the process of making ferric oxide, Fe_2O_3, a great advantage is said to be obtained, as the magnetic oxide Fe_3O_4 can be calcined and reduced to the red oxide Fe_2O_3 at a temperature of 800° Fahr. in about two hours—there being no combined water of hydration to drive off; whereas a temperature of about 2000° Fahr. for about five hours was required to calcine and reduce the ferric hydrate $Fe_2(OH)_6$ to the ferric oxide Fe_2O_3.

Anti-Vibrator for Incandescent Mantles.

OULTON, J., and NEWHOUSE, W. A., of Bradford.

No. 15,527; July 3, 1909.

This is a "Patent of Addition" to No. 6700 of 1909, with the object of providing a simple means for increasing the effect of the interposed vertical open spiral concentric spring in combination with the transversely divided mixing-tube of the burner in absorbing any shock.

For this purpose, an additional support is supplied to the concentric spring and divided mixing-tube, in order that they may always retain the burner, mantle, and other parts of the apparatus in a vertical position (with due regard to any vibration of the parts caused by shock) "without in any way destroying or reducing the flexibility of the tube, but, on the other hand, increasing the qualities of the anti-vibratory action."

This is effected by inserting a second or inner supplementary open concentric spiral spring in the divided mixing-tube extending throughout the interior of the concentric spring mentioned in the earlier specification. The ends of this inner concentric spring rest against the interior of the shoulders of the upper half of the divided mixing-tube, and the gas-nozzle is screwed into the lower half of the divided burner.

Regulators for Incandescent Gas-Burners.

NEUE KRAMERLICHT G. M. B. H., of Charlottenburg, Germany.

No. 23,545; Oct. 14, 1909. Date claimed under International Convention, Dec. 8, 1908.

This invention relates to a development of the apparatus described in patent No. 11,122 of 1908, in which a reservoir, divided into two chambers by a flexible plate, is used in order that, after closing the conduit leading to the main flame or to the pilot flame, the contents of the chamber communicating with the conduit in question can be utilized in this conduit for supplying the expiring flame and cause the latter to remain burning for some time longer, so that the other burner which the gas does not reach immediately the cock has been opened may certainly be kindled.

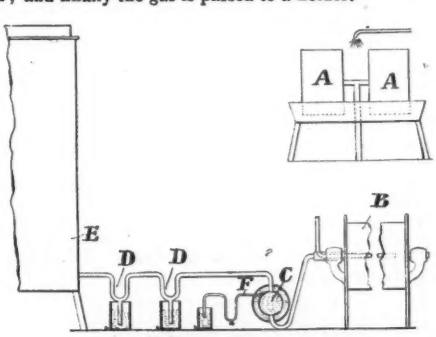
The device is constructed in such a manner that the lights can be turned on and off not only in the separate compartments of the railway carriage, but also from the main stop cock, which is generally located at the end of it; while in each case, owing to the automatic operation of the auxiliary reservoir, the kindling of the flame that it is desired for the time being should burn is ensured. With this object, a cut-off device is provided in the auxiliary reservoir for the bye-pass conduit leading to the pilot burners; this device being connected with the flexible plate, and being automatically operated when the path for the gas is altered.

Producing Gas from Peat.

OLIGNY, J. D., and PEAT GAS AND COAL COMPANY, of Montreal.

No. 23,760; Oct. 16, 1909.

According to this invention, the peat is taken in its natural moist state, crushed, and sprinkled with petroleum oil; and then subjected to intense heat—air being injected, preferably by forced draught, to mingle with the gas from the peat during the heating step, so as to lode the gas with air. The air-laden gas is then passed through liquid tar for carburetting purposes; the bye-products are withdrawn by condensation; and finally the gas is passed to a holder.



A Peat Gas-Producer.

The illustration shows merely the outline of the plant used.

The first step in the process is to destroy the capillary nature of the peat by placing it (say) under crushing rollers. During this step, it is saturated with petroleum or other hydrocarbonaceous oil. The peat so pulped and charged with petroleum is placed into a retort B, and "baked" until the mass becomes thoroughly coked and relieved of all the gas. During this step, air is injected (preferably by forced draught) into the retort. The gas from the retort then goes through a carburetting chamber C containing tar, preferably obtained as a bye-product from the peat itself; then through suitable pipes and condensing arrangements D, where it drops the bye-products into suitable receptacles; and finally it passes into a holder E.

The gas on leaving the retort is, as mentioned, laden with air. In this state it reaches the carburetting chamber containing the tar; and in this cooled chamber the mixed air and gas is carburetted, and much of the tar carried from the chamber C with the gas drops back into the chamber from above. The overflow of the chamber is taken care of by a syphon pipe F and receptacle attached.

The condensing of the gas further on in the process will, the patentees assert, cause the exusion from it of any further excess of tar and other bye-products, as also, later on in its flow, the exusion of alcohol; the gas "finally reaching the gasholder with its illuminating, heating, and explosive properties intact and generally in first-class commercial condition."

CORRESPONDENCE.

[We are not responsible for opinions expressed by Correspondents.]

The Coalite Patents.

SIR,—Our attention has been drawn to the statement in your issue of the 10th of May last, *re* the above, and to Messrs. Edward Evans and Co.'s reply thereto, and your comments on that letter, in your issue of the 17th of May. Seeing Messrs. Edward Evans and Co. do not seem to have replied to your comments, we, as the Patent Agents acting for the Glasgow Syndicate referred to, beg to confirm the statements you make as being substantially correct.

The Coalite Company were unsuccessful in opposing our clients' patent on the ground that the invention described in our clients' specification was covered by what they were pleased to consider their master patent—the patent cited in their prospectus. Their claim, therefore, to a monopoly (in this class of smokeless fuel) has been effectively "knocked on the head."

Further, both ourselves and Counsel engaged on this case regard the invention covered by our clients' patent as of equal, if not greater, value to that of the "master patent" of the Coalite Company, as our clients' process and claims disclose advantages which are not even foreshadowed in any way in the Coalite Company's specification.

With this information before us (which is equally well known to Messrs. Edward Evans and Co.), it is not surprising that they have not replied to your *addenda* to their letter, nor that you have not hitherto "corrected the statements" in regard to the Coalite Company's patents which Messrs. Edward Evans and Co. asked you "to be good enough to do."

EDMUND HUNT AND CO.

121, *West George Street, Glasgow,*
June 15, 1910.

[It is not at all surprising that Messrs. Edward Evans and Co. did not reply to the editorial note appended to the letter from them published on May 17, although it would have added to the interest of the carbonizing world had they done so. Even now we should much like to know the grounds on which they alleged that the statements made in our columns were "absolutely untrue." If they were "absolutely untrue," why be reticent over the matter? What have they to say, too, to the substantial corroboration of our statements by Messrs. Edmund Hunt and Co.? We said before there seemed to be a little bit of bounce about the letter of Messrs. Edward Evans and Co.; and there is confirmation in the above communication.—ED. J.G.L.]

PARLIAMENTARY INTELLIGENCE.

HOUSE OF LORDS.

The following further progress has been made with Bills:—

Bills brought from the Commons, read the first time, and referred to the Examiners: Bristol Gas Bill, Egremont Urban District Council (Gas) Bill, Exmouth Gas Bill, Exmouth Urban District Water Bill, Mountain Ash Water Bill, Slough Water Bill.

Bills read a second time and committed: Gas Orders Confirmation Bills (Nos. 1, 2, and 3), Glasgow Gas Consolidation Bill, South Hants Water Bill, Water Orders Confirmation Bill, Worksop Urban District Council Bill.

Bill Royal Assented: Farnham Gas and Electricity Bill.

The Southampton Corporation have petitioned against the South Hants Water Bill.

The Abertillery and District Water Board Bill, Brighton and Hove Gas Bill, the East Grinstead Gas and Water Bill, the Glasgow Gas Consolidation Bill, and the Slough Water Bill have been referred to a Select Committee, consisting of the Duke of Bedford, the Marquis of Bristol, the Earl of Westmorland, Lord Digby, and Lord Basing; to commence sitting to-day.

HOUSE OF COMMONS.

The following further progress has been made with Bills:—

Lords Bill read the first time and referred to the Examiners: Great Grimsby Gas Bill.

Lords Bills reported, with amendments: Matlock Bath and Scarthin Nick Urban District Council Bill, Thorne and District Water Bill.

Bills read the third time and passed: Bristol Gas Bill, Egremont Urban District Council (Gas) Bill, Exmouth Gas Bill, Exmouth Urban District Water Bill, Gowerton Gas Bill [Lords], Mountain Ash Water Bill, Slough Water Bill.

Bill withdrawn: Staffordshire Potteries Water Bill.

The second reading of the Gas Companies (Standard Burner) Bills [Lords], which was on the paper for Tuesday, was deferred till Thursday, and then till yesterday.

The Cambridge Water Bill, the Kingswood Water Bill, and the Water Provisional Order Bill have been referred to a Select Committee, consisting of Sir Luke White (Chairman), Mr. Paget, Mr. Lundon, and Mr. Newman; to meet next Thursday.

The water-works of the Brighton Corporation have been contributing to the rates ever since 1876; the grand total received from this source having been £178,000.

LONDON COUNTY COUNCIL (GENERAL POWERS) BILL.

Gas Companies and the Smoke Nuisance.

Among the provisions contained in the London County Council (General Powers) Bill, which came before the Local Legislative Committee of the House of Commons last week, it is sought in Part IV., which deals with smoke nuisance, to amend and extend section 24 of their Act of 1891, to enforce certain provisions of the Act of 1891, and to expend moneys in investigating and advancing measures in respect to smoke consumption and abatement of nuisance arising from smoke.

The Gaslight and Coke Company and the South Metropolitan Gas Company, in a joint petition against the Bill, strongly object to the proposed alteration of the Act of 1891 and to the granting of the further powers sought, which, they contend, will seriously interfere with the carrying on of their statutory duties in connection with the supply of gas. They further contend that there are other provisions in the Bill which affect their rights and interests, and that not sufficient clauses are contained therein for their protection.

Mr. J. D. FITZGERALD, in opening the part of the Bill relating to smoke nuisance, said the smoke nuisance in London was a very real nuisance, and one of the main causes of the thick, black fogs prevailing there in the winter. If they could prove that black smoke in sufficient quantities to be a nuisance was being emitted from a chimney, conviction followed. But, unfortunately, in a recent case, a loophole of escape had been discovered by the offenders; and in the Lots Road case, it was proved by scientific witnesses to the satisfaction of the Magistrate that the smoke was dark brown or dark grey. It was really impossible to prove that the smoke was absolutely black—it was hardly ever, if ever, absolutely black. There were other serious defects in the existing law. With regard to statutory undertakings, they varied enormously. In some instances they were subject to the ordinary law of nuisances, and in others they were not. In some cases it was almost impossible to find out whether or not they were subject, because part of their works had been authorized by Parliament and part had not; and it might be contended that a chimney on one side of a works was immune, while one on the other side of the works could be proceeded against. Under the Gas-Works Clauses Act, gas-works were specially not freed from any liability with regard to nuisance. But gas-works were so admirably managed that they hardly ever created a nuisance. He was not aware of any case in London where a gas-works had of recent years been charged with creating a nuisance; and he would be much surprised, though there were two gas companies in opposition, if it was said that any nuisance were caused by them.

Mr. *James Ollis*, the Chief Officer of the Public Control Department of the London County Council, gave evidence in support of the Bill.

In cross-examination by Mr. BALFOUR BROWNE, K.C. (who appeared for the Gas Companies), witness said he knew the difference between black and very serious smoke. He thought, generally speaking, that smoke could be prevented. In proceedings under the Public Health Act, in order to establish a nuisance, they had to show that it was not a mere accident, that it was not temporary, and that it had injured some person or some body. The smoke must be black, and in such quantity as to cause a nuisance. It would be somewhat difficult to say how much of the smoke in London was produced by manufacturers and how much by private chimneys. He thought that the conditions were improving in regard to gas companies putting in gas-stoves. Some years ago, they had a very strong complaint against one of the gas companies in regard to smoke.

Mr. BALFOUR BROWNE: Do you know that there is very little smoke when charging a retort?

Witness: We are not worrying over a little smoke.

When the coke is drawn, it has water thrown over it; and steam and smoke must be produced?—Steam would be prominent, and smoke, too.

Do you know that the best-managed works in the world cannot avoid that?—I do not know that there are decreases of the amount of smoke that can be produced under these conditions. It entirely depends upon the care exercised.

I am asking you to assume that both the Gaslight and Coke Company and the South Metropolitan Company have not been complained of, and are managing their works as well as possible?—I am not going to assume that any local authority would take action against a manufacturer for accidental cases of emission of smoke.

Would it not be fair, if you are going to take away this word "black," that the emission should continue for a certain length of time, and this should be mentioned in the Act?—I do not know that.

If you could agree as to what was a requisite amount of smoke to be allowed in smoke cases?—I think you might get a worse condition even than you have at present. If you provide exceptions, you will place local authorities in great difficulty. Under the proposed powers, it would be on the local authority to prove that the smoke was a nuisance; and the manufacturer is protected by the London stipendiary magistrate.

Mr. BALFOUR BROWNE said one was protected if one used the best practical means with regard to a furnace; but one had no such protection in the case of a chimney emitting black smoke. The only protection was the word "black."

The CHAIRMAN said it seemed to him there was some protection in the words "in such quantity as to be a nuisance."

Mr. FITZGERALD, upon re-examining, said that if one had not a proviso in one's Bill, it might be necessary to prove negligence; and, if the contention of the other side was correct, it might be that if it were proved that a chimney was sending forth black smoke in such quantities as to be a nuisance, they would be able to meet that by saying there was no negligence on their part.

Witness, replying to a question by Mr. FITZGERALD, admitted that well-managed gas companies were very rarely complained about for creating nuisance. He also agreed that if a gas company did not look carefully after its business, it would create a nuisance.

Mr. *W. H. Booth*, a member of the American Society of Civil Engineers, next gave evidence. He said the objection to smoke was twofold—first in the nuisance to the public, and, secondly, in the waste to the person who burnt the fuel. Smoke was caused by imperfect combustion. To experts, there were two classes of smoke—black and green. Black smoke was the result of the sudden chilling of hydrocarbon gases distilled from the coal before combustion was complete. The hydrogen burned, and carbon was thrown out in the form of soot. Green smoke was crude gas from coal which had never attempted to burn, as it was got in gas-works, unpurified. Black smoke might be brown or grey, or a combination of these different shades, depending upon the amount of carbon in it. Both qualities were objectionable things to discharge into the atmosphere. The appearance of what was known as green smoke was seen when a shovelful of coals was thrown on to a bright fire. This happened frequently with boiler furnaces. It was possible to prevent the mischief at comparatively little cost. Stoking should be done on the coking system. The smoke should be evolved gradually.

In cross-examination by Mr. BALFOUR BROWNE, witness agreed that there were occasions when it was necessary to stoke suddenly. In starting a boiler absolutely from the cold, they must make smoke. Bituminous coal was necessary for the manufacture of gas; but there were furnaces constructed which burnt bituminous coal smokelessly. In this case there would be no impropriety in saying that the person manufacturing the gas should be responsible unless he were using the proper kind of furnace.

Dr. *H. Des Voeux* said he had made a special study of the subject. With regard to the regulations in other countries, he thought "dense" was a very common word, and there were such words as "dark" and "dark grey." He was Treasurer of the Coal Smoke Abatement Society, which was founded in consequence of the great evil of smoke in London. He placed figures before the Committee showing the number of factories that had been reported for smoke nuisance.

In cross-examination by Mr. BALFOUR BROWNE, witness said they had done their best to instigate the County Council to promote the Bill. In London they had done very well towards lessening the evil; but they had not done sufficiently well. The Society's Inspector gave evidence in the Lots Road case; and the only difficulty was that he could not get the Magistrate to believe him. The prosecution failed because the witnesses who swore that the smoke was black were not believed. His (witness's) opinion was that no smoke was absolutely black.

The hearing was adjourned till to-day (Tuesday).

WATER SUPPLIES PROTECTION BILL.

The Joint Committee of the House of Lords and the House of Commons who have been charged with consideration of the above Bill met again Thursday, the 9th inst.—Lord MACDONNELL presiding.

The EARL OF ONSLOW, Chairman of Committees in the House of Lords, said it had been assumed that because companies or undertakers had power under their Special Acts to acquire land by agreement they had also power to sink wells on land so acquired without applying to Parliament for authority to do so. In 1907, the parliamentary authorities began to realize that it was desirable that where companies came to Parliament a clause should be inserted which would prevent the sinking of wells or the construction of any works except those which were auxiliary to the main works of the undertaking; thus carrying out what was decided in the Frimley and Farnborough case. The "wells" clause, as it was called, had accordingly been inserted in nearly all Bills since 1906, and in all since 1907. This clause applied only to undertakings in respect of which application had been made to Parliament; and the effect of clause 3 of the Bill would be to extend it to all existing undertakings. This was right and proper; and he failed to see where any hardship would arise except in a limited number of cases—that was to say, in cases such as the Barnet Company, in which the undertakers had received authority from Parliament to exercise the powers conferred on them by clause 12 of the Water-Works Clauses Act, 1847, and had already begun work. If the Bill passed, these undertakers would no longer be able to proceed with such works. He could see no reason why in future, whenever water undertakers desired to sink wells, they should not come to Parliament with a Private Bill or proceed by way of Provisional Order—a very much less expensive procedure. There might be some difficulty in including within the purview of the Bill small local authorities who were exercising powers under the Public Health Act. He had been unable to ascertain how many of these local authorities there were. It was suggested to Lord Onslow that the case of small authorities who had neither power nor money to apply to Parliament would be met by substituting application to the Local Government Board for application to Parliament. He replied that proceedings before the Local Government Board might be (he did not say that they would be) of a "hole and corner" character, and, moreover, proper notice might not be given to all the parties concerned. The Local Government Board usually held an inquiry locally; but they were under no obligation to do so. Possibly the difficulty might be met by making it obligatory on the Local Government Board to hold a local inquiry in every case. In this event, everyone in the locality would know what was being done; and thus the main object of the "wells" clause would be attained. In case of acquisition by a local authority of land otherwise than by agreement, a local inquiry was necessarily held, and the purpose for which the land was required would come up. He would exclude local authorities from the right which they at present enjoyed of acquiring land by agreement, unless means were established of making the matter public and giving the parties interested an opportunity to be heard. If the Frimley decision were upheld, clause 3 of the Bill might be unnecessary; but this decision might be appealed against and reversed. With regard to clause 4, which related to compensation, he was of opinion that protective clauses in existing Acts of Parliament ought to be safeguarded. As to underground water, there was a good deal of difficulty in fixing a general limit of possible injury that would be proper and adaptable to all geographical conditions Water-works in chalk strata and water-works in clay strata affected areas of very different size. An area of possible damage in one case might be too much or too little in others. Each case should be considered on its merits. If large water-works were established and there was diminution of the supply of water in neighbouring ponds and streams, it was reasonable to infer that the cause of the diminution was the water-works. To ascertain if there had been a diminution, expensive machinery would have to be erected. It would be hard on the owners of the water that they should be called on to undertake this expense in order to prove at some future date that the supply had been diminished by the undertakers. It was common to insert a provision that the undertakers should establish gauges and so forth.

The CHAIRMAN remarked that the erection of apparatus to register the rise and fall of water would be a protection which undertakers would provide in their own interests. Why throw on them the burden of proving that no damage occurred in consequence of their works? To do so would be to reverse completely the ordinary rule of procedure.

Lord ONSLOW replied that one of the main justifications for the proposal was the difficulty which, in the absence of methods of testing, the claimant would experience. He doubted, moreover, whether all companies and undertakers would go to the expense of putting up gauges if they had not to prove their case, and if they knew that the *onus probandi* rested with the claimant. He did not think the time within which a claim for compensation must be made should be limited. The water taken might be very much greater at the end (say) of ten years than at the time the works were erected. Wherever practicable, compensation should be in water, not money. With regard to clause 5, he recognized the soundness of the principle that every district had a natural inherent right to the water in it, and that it was a great hardship to take the water away without making adequate provision for the supply of the district. But when they came to supplying all the districts between the place at which the water was taken and the place to be supplied, it seemed that this was going a little far. A proposal was made by the London County Council some years ago to bring water from Wales to London. If every district on the way was to be supplied, it might be that there would be very little left for London. It seemed that only such water as was not required for the supply of the place to which it was taken should be given to the localities *en route*. Under the Bill, the power of asking for water—not necessarily of getting it—was strictly limited to district councils. Questioned as to whether the protection afforded by the fact that the Local Government Board could refuse to require a supply to be given *en route* was not sufficient, Lord Onslow pointed out that a decision of the Local Government Board, once given, would stand for all time. The population of London was increasing very rapidly; and a supply of water brought from Wales might a few years hence be wholly inadequate to supply London and the places *en route*, although in the earlier stages it might have been sufficient for both. The matter should therefore be subject to revision. As the Bill stood, difficulties of this sort might arise.

Mr. PERCY GRIFFITHS, representing the Association of Water Engineers, said he gathered that Lord Onslow admitted that in principle the exemption of local authorities working under the Public Health Act, 1875, was possible. What was his view with regard to a similar exemption being extended to water undertakings working under the Gas and Water Works Facilities Act—that was to say, under Provisional Orders granted by the Board of Trade, a department in many respects the equivalent of the Local Government Board?

The CHAIRMAN remarked that the two cases were not on all-fours. The body in one case represented the ratepayers; while the body in the other case was independent, and worked for its own profit.

Lord ONSLOW said he thought the Chairman had answered the question.

Mr. GRIFFITHS said he wished to raise another point. The engineers he represented were considerably affected by the possibility of clause 3 preventing necessary duplication of boreholes, wells, and so forth. Did Lord Onslow anticipate such an interpretation of the clause as would have that effect?

Lord ONSLOW thought the intention of the clause was that, wherever it was intended to take or intercept water not at present taken or intercepted, the undertakers should go to Parliament for the necessary powers, and, incidentally, give due notice of their intention.

Mr. GRIFFITHS said the duplication to which he referred meant second plant for accomplishing the same purpose—a stand-by, not plant for doubling the quantity withdrawn.

The CHAIRMAN said the two sets of machinery often worked at the same time.

Mr. GRIFFITHS said he did not refer to such cases.

Lord ONSLOW said that if duplication meant that twice as much water was to be abstracted from the same area as Parliament had sanctioned in a measure that had been before it, the undertakers ought to go to Parliament again.

Lord DESBOROUGH remarked that if duplicate machinery were wanted merely as a stand-by, it was not intended that the undertakers should have to go to Parliament.

Mr. GRIFFITHS said it was not usual to define exactly the works—the number of engines, the number of pumps, and so forth. Members of his Association did not wish to have to promote a Bill in order to carry out works they might reasonably execute under a former Act.

Mr. H. R. CRIPPS, on behalf of the Metropolitan Water Board, said he did not desire to put any questions to witness. His clients thought it better that the facts and figures which they would have to place before the Committee should be given by their own witnesses.

Mr. A. V. FRERE, on behalf of the Barnet District Gas and Water Company, pointed out that where, for instance, a pumping-station had been authorized without any specification as to the quantity of water that might be taken, it would, from the passing of the Bill, be stereotyped, so to speak; and they would never be able to obtain more water from it. Did witness think that fair?

Lord ONSLOW replied that he thought it necessary that the Committee should consider very carefully the definition of "new works." A reasonable increase of existing works would probably not be objected to. The objection was to new works. Where new works were in progress under existing powers, some exception should be made.

Lord DESBOROUGH: Do you agree with the attitude that if a man

possesses a plot of land he should have unrestricted rights for all time of grabbing what water he can take from it?

Lord ONSLOW: No.

Mr. PELHAM, of the Board of Trade, explained the practice of the department with regard to the granting of Water Provisional Orders; pointing out that while the Board of Trade had power with regard to companies the Local Government Board had power with regard to local authorities. It did not appear to the Board that the Bill would seriously affect undertakings authorized by Provisional Orders of the Board, except in places where special power had been given to the undertakers to sink wells on land not specified in the Order. The Board saw no reason to suggest that the undertakings of companies authorized by Provisional Order should not be subject to the same restrictions as those imposed on companies who obtained their powers direct from Parliament by Special Acts. With regard to clause 3, many companies had acted on the assumption that they were entitled to sink wells on any land belonging to them, whether such lands were specified for the purpose or not. The Board had very readily followed the practice of Parliament in inserting the Model Bill clause with the object of definitely prohibiting such action. The view of the Board had always been that legally companies who were undertakers acquired no general powers to sink wells other than those specified in the Provisional Order. They had never considered that section 12 of the Water-Works Clauses Act, 1847, gave them power to sink wells on lands acquired by agreement and not specified in their Act. They had frequently refused to authorize capital asked for when the estimates showed that the money was wanted for the construction of works for which the promoters had not obtained statutory sanction. It appeared to the Board that full notice ought always to be given in the locality concerned of any proposed abstraction of water, in order that persons likely to be affected might have an opportunity of obtaining protection for their interests. So far as clause 3 was merely declaratory of the general law, it seemed to be unnecessary so far as companies were concerned; but where special powers had already been granted by Parliament in excess of the general law, as in the case of the Barnet Water Act, it would appear to have the effect of restricting and amending these powers. It was not customary, by means of a Public General Act, to repeal or amend powers specifically granted by a Special Act. In most cases, the effect of clause 3, so far as companies were concerned, would be merely to declare the present law. The Board hesitated to recommend the application of clause 3 to existing undertakings, except possibly as a condition of granting further statutory powers. The clause might be particularly hard on companies who had bought land by agreement in reliance on special powers in their Act to sink wells. The Board agreed with the principle of clause 3, and thought it should apply to all new undertakings of companies. As regarded clause 4, there did not appear to be any objection to the general principle that compensation should be given to the owners of private water supplies for injury caused by the abstraction of water for public purposes. But the clause seemed to be open to the objection that it was impossible, by a general enactment, to have a satisfactory definition of "protected area," for which purpose it would be necessary to consider the geological and other conditions of each particular district. The clause was also open to the objection that it threw the onus of proof on the undertakers. It seemed preferable to deal with each case on its merits, and to insert such protective provisions as were required. The obligations resting on a company under a clause of this kind were very indefinite, and might have the effect of discouraging the application of capital to the provision of new undertakings, or to the extension of existing undertakings. It would almost certainly tend to discourage an existing company from making provision for future requirements by timely extensions of their present works; and to this extent it might be detrimental to the public interest. As regarded clause 5, it would be practically impossible to grant powers by a Provisional Order which would involve bringing water from a considerable distance; and the experience of the Board of Trade did not enable them to offer any observations on the operation of this clause.

Mr. MIDGLEY TAYLOR said that the smaller district councils were not too ready, under present conditions, to provide their districts with water, even under the Public Health Act of 1875; and if application had to be made to Parliament by these authorities, the fear of the expense would act as a deterrent, and many authorities would not seek the necessary powers by Act of Parliament, whereas they might probably proceed by Local Government Board inquiry. In his experience, urban and rural district councils exercising their powers under the Act of 1875 took water in their own neighbourhood; and there was no need therefore for the Bill to apply to them. The Local Government Board, when sanctioning wells and borings by district councils, did not consider the damage which might be done to adjoining private supplies. Granting Provisional Orders, therefore, under section 303 of the Public Health Act, 1875, should not be excluded from the Bill. The sinking of wells and borings by authorized undertakers should receive the express sanction of Parliament. He agreed generally with the proposal that compensation should be given where private supplies were injured by the abstraction of water for a public supply, with the provision that where water was taken from any district for supplying communities outside that district the districts whence the water was taken and through which it was conveyed should be entitled to demand a share of such water, provided that the undertakers should be entitled to a certain quantity per head per day for their own district. He also approved of clause 4.

Mr. URBAN A. SMITH, the Surveyor and Engineering Adviser to the Hertfordshire County Authority since 1875, also gave evidence in support of the Bill.

Mr. G. L. COURTHOPE, M.P., on behalf of the Central Associated Chambers of Agriculture, gave evidence. He said that body had had represented to them the evils of the land being drained, and they had been asked in many cases by local agricultural bodies to represent their interests in opposition to the Bills promoted by water companies. A great many Acts had been passed without any action being taken by the Local Government Board; and it was admitted by the Local Government Board that they had not power to protect the consumers of water. The Central Associated Chambers had endeavoured to protect the consumer by blocking the Bills promoted by water companies; and in many cases fairly satisfactory clauses had been obtained. Clause 3 provides that: "Notwithstanding anything contained in any Act of Parliament or Provisional Order, no authorized undertaker shall, after the passing of this Act, sink any well upon, or construct any other works for taking or intercepting water from, any land unless those works, and the lands upon which the same are to be constructed, are specified in an Act of Parliament." He said it was very desirable that there should be a model clause of this nature. Where a supply was affected by a water company, either the supply should be made good or compensation should be paid. A protective clause, either by agreement or arbitration, should be inserted. This Bill was the practical embodiment of the protective clauses which had been inserted in many Bills that had passed through the Houses of Parliament in the last few years; but though the Bill was not necessary for the purpose of protecting the public against damage, it would prevent unnecessary trouble, delay, and expense. The Bill was rather in the interests of the poor and weak than in the interests of the rich and strong; and it did not attempt to do anything or impose any obligation which had not already been recognized by one House or the other. By their opposition to individual Bills, the Central Chamber of Agriculture had succeeded in establishing precedents; and it was becoming more and more easy to look after the interests of agriculture in the House than had been the case in the past. There was not now the slightest chance of a Private Bill forcing its way through Parliament without some clause or other being inserted to protect any interests that might be threatened. There was ample protection with regard to the depletion of water by pumping.

Lord ROBERT CECIL said he had taken a lot of interest in the whole question of water supply; and he was of opinion that a great deal of unnecessary litigation, and very often unnecessary hardship, could be avoided if this Bill received the sanction of Parliament. With regard to the general law, he agreed substantially with the evidence of Mr. Lithiby. Of late years, Parliament had taken a certain definite view with regard to the matter which might not by some be regarded as the law of the day. When he first began to practise in these rooms, it was difficult to get *locus* to be heard—say, in regard to injury to a well. But Parliament must consider the actual state of things that now existed; and they could not put out of their minds the fact that the demand for water had enormously increased. There used to be a theory among water engineers that there was a great stream of water under the ground, and that therefore one could pump as much as one liked without injuring the stream. But this really was incredible. He had no doubt that the water pumped from a well diminished the amount that otherwise might find its way into a spring or stream in the neighbourhood. The time had certainly come when there should be general legislation on the subject. He thought very strongly that some limitation of the statutory rights of the undertakers ought to be imposed; and it should be done by a General Act. As a rule, some specific limitation was put in; but if it were done by a General Act, it would make it so much better for everybody concerned. In a matter of this kind, everybody should be protected. With regard to the advantage to water undertakers, he said the rich landowner could petition Parliament. But the only remedy of poor people was to induce the Member for their Division to block the Bill; and he was very strongly of opinion that it was better for everybody that there should be a law which was safe than one which at present was unsafe. There was no reason why this Act should not apply to Provisional Orders. Where a large source of water was tapped, the principle had been generally recognized that the people living in the district from which the water was taken ought to be supplied first. Although he was opposed to giving discretionary powers to Government Departments, he thought the only way of deciding certain small difficulties would be to allow the Local Government Board to decide. The sort of case he had in mind was where a water supply was taken from a district which, in the course of a few years, might need it, in order to benefit a growing manufacturing town.

The Committee adjourned till Thursday last.

Winding-Up of the National Lighting Corporation, Limited.

A petition for the compulsory winding-up of this Company was heard before Mr. Justice Swinfen Eady last Tuesday. The Company was formed in August, 1909, with a capital of £1000, in £1 shares, and the petitioner (one Lange) was a judgment creditor for £437 in respect of goods sold and delivered. His claim was disputed by the Company; and, under an order made by Mr. Justice Neville, the matter was referred to Mr. Malcolm Macnaghten as Arbitrator, who had found in favour of the petitioner, the amount due to whom was about five-sevenths of the total indebtedness of the Company. Resolutions purporting to voluntary liquidation were supposed to have been passed; but the procedure, as his Lordship observed, was full of irregularities from beginning to end. An attempt to increase the capital by issuing 2000 shares of 1s. each was equally irregular, as the resolutions were not properly passed. His Lordship made the usual order for compulsory winding-up.

Winding-Up of the Beaufort Gas Company.

At the Tredegar County Court last Tuesday, before His Honour Judge Hill Kelly, Mr. A. Parsons applied for the compulsory winding-up of the Beaufort Gas Company. Mr. Parsons said the petitioners were Messrs. Robert Cort and Sons, and there was no opposition. On the 13th of January last, they recovered judgment for £59 6s. 9d. and costs; and when execution was levied, the Sheriff found a Receiver in possession on behalf of the debenture holders. Debentures to the amount of £3700 had been issued; and since the debt had been incurred, 30 others of £10 each—27 being held by the Managing-Director. Frequent applications had been made for payment, but without success. The application had been made before his Honour at the previous Court, when it was adjourned in the hope that the applicants' claim would be met; but nothing had been done. He applied that the Official Receiver should be appointed Liquidator. His Honour asked if the Company had any parliamentary powers. Mr. Parsons replied that they had not. The application was granted.

MISCELLANEOUS NEWS.

THE RESIGNATION OF MR. W. R. HERRING.

A Special Meeting of the Edinburgh and Leith Gas Commissioners was held on Monday, the 13th inst., to consider the resignation of Mr. W. R. Herring. There was a full attendance, presided over by Lord Provost BROWN.

The CLERK (Mr. J. M'G. Jack) read Mr. Herring's letter of resignation, which was as follows: "It is with many feelings of regret that I now place in your hands my resignation as Chief Engineer and Manager of your undertaking. My professional future, however, necessitates my taking this action. For some time past I have been at least endeavouring to defer this otherwise inevitable step. But it is now considered by my friends to be adverse to my interests to further delay following my profession as a civil engineer in London. In doing so, I would like to place on record my sincere thanks to the Commissioners for the unstinted confidence they have shown towards me since I came to Edinburgh, for the great opportunities they have given me in my professional sphere, and for the unfailing courtesy that has invariably been extended towards me; and my wish is that the undertaking may be even more successful, both from a practical and financial point of view, in the future than it has been in the past." The Clerk said he had a further letter from Mr. Herring, in which he said: "In handing you the enclosed document, I believe I am right in saying that the terms of my appointment necessitate my giving three months' notice to terminate my engagement. If such is the case, I would like you to convey to the Commissioners that I do not wish to bind them to this particular period, as (say) Martinmas term would be a convenient period for myself; and I would further suggest that the Commissioners consent to name Martinmas term as the period when I should vacate Granton House."

Lord Provost BROWN said he was sure it was not the desire of any of them that there should be a discussion that day. It came as a surprise, to many of them at any rate; and he was sure they all regretted very sincerely the position which Mr. Herring considered it necessary to take up. He thought the right course would be to remit the matter to a small Committee; and if that were the feeling of the Commission, they might name the number they wished to act. The first thing to do was to consider the delicate position in which they were placed. There were various interests to be considered; and he thought the course he suggested would be in the interests of the Commission. They must not do anything hostile.

Bailie STEWART: Is this resignation final?

Lord Provost BROWN: I have no idea whatever; we must see Mr. Herring.

Provost SMITH, of Leith, extremely regretted that Mr. Herring should have sent in his resignation. They, who had been there for some years, knew the very great value he had been to them. He came to them when the old works were in use—producing gas in a somewhat antiquated and expensive manner—and, acting upon his recommendation, they decided to adopt a scheme for removing the gas-works to one site—viz., Granton. This had all been carried out, without employing a consulting engineer, at a cost of over a million sterling, and carried through within the time, at several thousand pounds less than the estimate. This had saved the Commissioners, in architects' and engineers' fees, between £25,000 and £30,000. They had found Mr. Herring to be an excellent business man, whose advice was always sound and reliable; and in this respect their loss was a very severe one. He approved of the suggestion that they should remit to a Committee, with the object in view of asking Mr. Herring to reconsider his decision, and remain with them some time longer; and failing that, that the Committee should have power to proceed to fill up the vacancy.

Mr. RAWSON thought it would be a very great mistake if, for any reasonable sum of money, the Commissioners should allow their Engineer to leave Edinburgh. Mr. Herring practically stood unique in the gas world.

The Commissioners appointed a Committee of seven, with instructions to first approach Mr. Herring, and with, in the event of failure to get him to reconsider his decision, a free hand in the procedure to be followed in filling up the vacancy, and to report.

STAFFORD GAS AND ELECTRICITY SUPPLY.

The Past Year's Accounts.

It was recorded in the last number of the "JOURNAL" that the accounts of the Gas and Electricity Departments of the Stafford Corporation for the year ended the 31st of March had been submitted to the Town Council and passed. We have since received a print of the accounts, signed by the Chairman of the Committee (Alderman Wright) and the Engineer (Mr. Herbert Pooley), and from them and the Committee's report the following additional particulars are taken.

The quantity of gas sent out from the works during the year was 202,436,000 cubic feet, compared with 203,843,000 cubic feet in the year 1908-09; and the unaccounted-for gas amounted to 2,156,643 cubic feet, or 1·07 per cent.—this figure being the lowest in the history of the concern. The total revenue was £33,596, and the total expenditure £18,315; the gross profit for the year being £15,281, compared with £14,754 for the preceding year. After deducting charges against the net revenue account, amounting to £7072, and adding the balance of £241 brought forward, there was an available balance of £8450, compared with £5660. In the Electricity Department there were sold 390,010 Board of Trade units. Of this quantity, 152,712 units were sold for lighting purposes and 212,139 units for power; while the public lamps used 8635 units. The total number of units sold in the year 1908-09 was 380,353. The equivalent of 893 eight-candle power lamps was connected to the mains during the year, and also ten additional motors. The revenue from all sources amounted to £4343, while the expenditure was £1865; the gross profit being £2478, compared with £2465. Charges against the net revenue account amounted to £2104; leaving a net profit of £374, which, added to £110 brought forward, came to £484.

According to an analysis of the accounts of the Gas Department by Mr. Pooley, the capital invested in the undertaking at the close of the year amounted to £40,446; being at the rate of £2 4s. 4d. per ton of coal carbonized, and 4s. 1d. per 1000 cubic feet of gas sold. The quantity of coal, &c., used for producing gas was 18,260 tons; the make per ton being 11,083 cubic feet, of which 10,858 cubic feet per ton were sold—or 97·93 per cent. on the make. The residuals sold per ton of coal were: Coke, 9·94 cwt.; tar, 11 gallons; sulphate of ammonia, 18·7 lbs.—the net proceeds from the sale of residuals being 73·1 per cent. on the cost of the coal. The net profit was equal to 8s. 11·89d. per ton of coal carbonized, and 9·93d. per 1000 cubic feet of gas sold. A similar analysis of the accounts of the Electricity Department shows that the returns from the sale of current were equal to 2·67d. per unit. The profit on the year's working was equivalent to 0·23d. per unit sold.

SALFORD GAS CHARGES.

The Special Meeting of the Salford Town Council to re-consider the question of gas charges was postponed from Wednesday last until to-morrow (Wednesday). It will be remembered that the Council at their last sitting rejected the Gas Committee's recommendation that the quantity of gas supplied to penny-in-the-slot consumers be reduced from 30 cubic feet to 27 cubic feet for a penny; that the charges for meter-rents be re-introduced; and that the price of gas to large consumers within and outside the borough be reduced, 1d. per 1000 cubic feet for consumers of 2,000,000 cubic feet and under 4,000,000 feet, and 2d., 3d., 4d., and 5d. per 1000 cubic feet to still larger consumers, in proportion to the amount consumed. There is every probability that the Gas Committee's proposals will be approved at to-morrow's meeting. The General Purposes Committee, which embraces the whole of the members of the Council, have already passed a resolution to this effect.

COVENTRY CORPORATION GAS AND WATER SUPPLY.

The Past Year's Working.

A gratifying result of the working of the Coventry Corporation Gas Department in the twelve months ended March 31 was laid before the Gas Committee at their meeting last Wednesday. The net profit is £18,191, compared with £2296 for the year 1908-9. It was decided to recommend that £4000 should be paid over to the general district fund in aid of the rates, that £13,000 should be set aside towards meeting the loss of capital occasioned by the abandonment of the old works, that £430 should be applied in payment of a bonus to workpeople in the department, and that the balance should be carried forward. It was also decided to recommend that the price of gas should be reduced 1d. per 1000 cubic feet to ordinary consumers, and 2d. per 1000 cubic feet to those who use prepayment meters. The Committee further recommended that the salary of the Engineer and General Manager (Mr. Fletcher W. Stevenson) be increased by £150 per annum.

The water undertaking of the Corporation has again yielded a satisfactory result on the year's working. The annual accounts just prepared show a net profit of £5577, against £2133 in the preceding twelve months. The Water Committee recommend that £3500 of the net surplus should be devoted to the borough fund in aid of the rates, and £539 transferred to capital account, representing one-fifth of the cost of promoting the Bill of 1907 by which the Corporation obtained a supplementary water supply under an arrangement with the Birmingham Corporation. The balance of £1538 is to be carried forward.

COLWYN BAY GAS-WORKS.

Suggested Improvements.

The Gas Manager of the Colwyn Bay Urban District Council (Mr. J. Smith) has presented a report on the condition of the plant, and submitted proposals for the improvement of the works and the better administration of the undertaking. He recommends methods for securing higher carbonization results, the purchase of lower-grade fuel, the provision of additional washing plant, additional steam-boiler plant, and new purifiers, the enlargement of all 6-inch connections in the works to 12-inch, the testing and sealing of the station meter, the assembling and enclosing of the gasholder valves, the provision of offices and a new weighbridge, and a better method of conducting sales of coke at the works, the treatment of residuals, the allocation of as much work as possible under a piecework system, the systematic testing of all meters, a hire-purchase system for the distribution of gas cookers, the introduction of automatic lighting for street-lamps, the registration of meters, stoves, &c., the reorganization of the distributing department, the fixing of a standard scale of pay to workmen, and the appointment of a storekeeper. The Gas Committee, he states, are at present selling gas at 2s. per 1000 cubic feet to other Council departments, and coke below the market price; and the gas and other expenditure for street lighting does not appear at its full value as a credit to the department. A true commercial return for comparison with other undertakings cannot be arrived at under these conditions; but if full credit for these items were given to the proper department, the balance would be at the disposal of the Council in a legitimate manner.

MALTA AND MEDITERRANEAN GAS COMPANY.

Small Effect of Competition.

The Ordinary General Meeting of the Company was held last Tuesday at the London Offices, No. 59-60, Gracechurch Street, E.C.—Colonel JAMES LE GEYT DANIELL in the chair.

The SECRETARY (Mr. A. W. Cooper) read the notice convening the meeting and the report of the Auditors; and the Directors' report and the accounts (which were noticed in the "JOURNAL" for May 31, p. 581) were taken as read.

The CHAIRMAN remarked that when the shareholders last met no one contemplated that the country was so soon to sustain the severe loss it had done in the death of the King; and it would be unbecoming in them now to transact the business before them without some brief reference being made to the sad event. Proceeding to move the adoption of the report and accounts, he remarked that he had prepared the shareholders during the last two or three years for a reduction in the amount of gas sold, in consequence of the naval establishments at Malta putting up electricity works for their own purposes, and after that in consequence of the military establishments having decided to purchase electricity from the Government at Malta, and to instal it, not only in their hospitals (which one could understand) but also in their barracks (which it was a little more difficult to comprehend, in view of the fact that economy was usually the ruling passion with such authorities). Bearing what he had said in mind, the proprietors no doubt looked for a considerable falling-off in the revenue; and yet, if they compared the balance carried over this year on the profit and loss account with that of the preceding twelve months (which was by no means a bad year), they would see that the difference between the two amounts was only about £100. Nevertheless, it was a matter of regret to a Company such as theirs that they should lose so good a customer as the military establishments had been to them in years gone by. But they had yielded to the arguments—which the Directors considered delusive arguments—in favour of the electric light. However, the controlling powers on this side would very shortly have an opportunity of making the comparison themselves, if they cared to do it, of the difference in cost of lighting the barracks by means of gas and of electricity. With regard to the profit and loss account, he might point out that, though the decrease in the cost of coal amounted to £498, the Company had used some 600 tons more. The actual cost per ton, he might mention, was 17s. 6d. last year, as against just over 19s. in the preceding twelve months; while the gas made per ton worked out at 10,718 cubic feet. Therefore they had not done so badly. The item of gas making showed an increase of £110, and that of maintenance an increase of £245. The policy of the Board had been, and always would be, to keep the works up to the highest possible pitch of efficiency. On the credit side there was a falling-off of £682 in the gas sold, expressed in sterling, and by measurement the sale was 119,562,000 cubic feet, against 122,459,000 cubic feet in the previous year. Malta was responsible for a falling off of £458 of this sum, and a decrease of 736,000 cubic feet to the general public, which worked out to rather less than 1 per cent. This was attributable to the increased competition of the electric light. He must give the electrical authorities credit for putting a tremendous amount of power into their competition. The shareholders must not think for a moment that he complained of competition. Far from it. When fairly carried out, competition was a very good thing; for it kept everybody up to the mark. Coke showed an increase of some £377; while, on the other hand, tar and pitch realized £14 less. All told, there was a balance left of £10,835. Now, as to the general revenue account, the items under this head spoke for themselves. In the general balance-sheet, the proprietors would have observed that the amortization account had attained the respectable amount of £38,000. On the other side, the investments stood at the same value in the books as the previous year; the market value of the day being also shown. With a class of securities such as the Company held (as mentioned in the accounts), he did not see any advantage in constantly changing the value in the books. The Sicilian stations—which he alluded to at the last meeting, and must refer to again now—had engaged the very close attention of the Board. Matters were now, he was happy to say, in a more healthy condition. The Foreign Office here had been good enough to state the Company's case to the Ambassador in Italy, with a view to his moving the Italian Government; and the Ambassador had shown himself not only ready to do so, but to continue doing so, in the interests of the Company. He was glad to take this opportunity of expressing the satisfaction of the Board at the value of the services which the Ambassador (Sir Rennell Rodd) had rendered to the Company. Matters, however, moved so slowly in that country that the Directors became impatient—and very properly impatient. "To-morrow" was the usual lethargic answer to anything like an appeal; and so the Board thought it desirable to despatch the Secretary, with the necessary powers, to Sicily—taking Rome on his way, so that he might see the Ambassador there. In one case in Sicily, Mr. Cooper succeeded in making arrangements with the authorities, who had so far kept to their engagement in the matter of paying up. With regard to Marsala, too, he was successful in negotiating for a renewal of the concession, to run till 1921, on such terms only as the Company were able to continue working there. Some of the conditions were of such an onerous character that the Directors could not have recommended the shareholders to continue operations there, but for what the Secretary had been able to accomplish. He was glad to tell the shareholders how much the Board appreciated the tact, energy, and ability which had enabled Mr. Cooper to bring about so good a result to the Company.

Mr. A. M. PADDON seconded the resolution. He remarked that he did not think there was anything in the statement of the Chairman with reference to the competition in Malta which need discourage a single one of the proprietors. It was following a well-worn track. The Company had regained every bit of the early loss; and this small temporary set-back he did not think had any high significance. Circumstances would certainly prove in Malta that economy was on the side of gas; and he thought this little indulgence in electric light would soon bring its lesson. Of course, in this battle with the electric light they had to remember that the old methods would not do. The two lights were not judged on their respective merits, but by the methods employed by those who were protagonists and antagonists of the systems. The electric light well pushed would beat gas, and bad gas well pushed would beat electric light. They must show enterprise and vigour, and be prepared to spend some money. The Board were displaying all these qualities in regard to Malta; and therefore it was possible to anticipate the regaining of the small loss which had to be recorded that day.

Mr. H. R. SIBSON said they might hope and believe that the suggestion made that this small set-back was only temporary was an accurate diagnosis. If, as had been said, bad gas well pushed would beat electricity, what might they suppose that good gas—such as they could assume was supplied in Malta—would do? It should knock electricity out of the field altogether. There was one point on which he would like a little information, if the Board thought it desirable to give it. It was in reference to the large item in the general balance-sheet "Sundry debtors." He noticed that this had crept up from £14,330 in 1908, to over £17,000 in 1909, and to £19,245 in the year under review. Of course, this figure was very considerable—representing, as it did, one-half of the amortization account. Had this occurred in connection with arrears in public lighting, private lighting, or what? Items of this kind, if they continued to grow, must ultimately be regarded, he might say, with anxiety both by Directors and shareholders. He had nothing but praise for the efforts of the Board, who, in face of the competition they had had to meet, had been able to present a balance-sheet showing approximately the same result as the previous year.

The CHAIRMAN said this was the very subject he referred to when he spoke of the action of the Foreign Office here, and to the mission of the Secretary to the Sicilian stations. At these two places there were municipal debts; and the larger sum was at Trapani, where judgment had been obtained. The arrangement, however, was that the judgment would not be enforced, provided the Government would assist in the way of finding funds. This was what Mr. Cooper had negotiated for. Marsala was also a poor place; and there, again, the Secretary had succeeded in making arrangements for the meeting of the debt. However, the Company's great strength was in the manner in which the Foreign Office here had assisted them. There was not the slightest hesitation on their part on the present occasion, any more than there had been on previous occasions when their aid was invoked. The Ambassador had quite made up his mind to push the Company's claims with the financial department of the Government of Italy, so as to get them to provide the funds themselves.

The report was then unanimously adopted.

The CHAIRMAN proposed, Mr. A. F. PHILLIPS seconded, and it was agreed, that the usual dividends should be paid on the first and second preference capital and a dividend of 4 per cent., free of income-tax, on the ordinary capital, making, with the interim dividend paid in December last, 6 per cent. for the year.

On the proposition of the CHAIRMAN, seconded by Mr. JOSEPH CASH, the retiring Director (Mr. Stephenson R. Clarke) was re-elected; and, on the motion of Mr. THOMAS WILKINS, seconded by Mr. F. R. SMITH, the Auditors (Messrs. R. Hesketh Jones and Thomas Guyatt) were also re-appointed.

The CHAIRMAN then proposed a vote of thanks to the officers. They were, he said, most fortunate in their staff.

Mr. SIBSON seconded the resolution, which was heartily passed.

Mr. COOPER, in acknowledgment, remarked that he had seen the officers abroad; and a more zealous lot of men the Company could not have at any of the stations. While speaking, he would like to refer to the kindness he had received from the Ambassador in Rome, who had the Company's affairs at his fingers' ends.

Mr. CASH, in proposing a vote of thanks to the Directors, congratulated them on the excellent accounts presented, which, he thought, showed the Company to be in sounder condition than it had occupied for many years past. So far as the competition of the electric light was concerned, there need be no fear. They had had the same sort of thing in England; and gas usually came out on top. From what he heard of some of the officials, they would maintain the business of the Company in every way.

The vote was seconded by Mr. SMITH, and cordially agreed to; and the CHAIRMAN'S acknowledgment brought the proceedings to a close.

BARROW GAS AND WATER SUPPLY.

The Borough Engineer and Surveyor of Barrow-in-Furness (Mr. Arthur Race) read a paper before the Lancashire and Cheshire District Meeting of the Incorporated Association of Municipal and County Engineers at their meeting in his town the first Saturday this month. He took for his subject "Barrow-in-Furness and Some of its Municipal Undertakings," in only a few of which readers of the "JOURNAL" are specifically interested.

As to street lighting Mr. Race said: Although Barrow claims to be modern and up-to-date in most matters, it must be confessed we are considerably behind the times with reference to street lighting. The author has recently obtained considerable information from other towns and presented a report on this matter, which report is now receiving consideration at the hands of the Highways and Lighting Committee. The following particulars may be interesting:

The total number of electric lamps is as follows:

Ordinary Arcs.	Incandescents.	Total.
78	149	227

The total number of gas-lamps is as follows:

Incandescent Four Lights.	Three Lights.	Two Lights.	One Light.	Intensified and Other Kinds.	Flat Flame.
—	—	2	63	27	1113

Total—Gas-lamps	1205
Electric lamps	227
Grand total	1432

The percentage of flat-flame lamps to the total number of gas-lamps in Barrow is 92·4 per cent., which compares with the percentage in 39 other towns of 21·2 per cent., or 71·2 more. In fact, only one town out of the whole number has a lower percentage of incandescent gas-lamps. On the other hand, the percentage of electric lamps to the total number of lamps (gas and electric) is 16, which compares with 10 for other towns. In 17 out of 44 towns from which replies were received, they have entirely replaced their flat-flame burners with incandescent burners. In 4 others they have almost discarded them (in no case have they more than 10); and in 5 others they are gradually replacing them.

The present flat flames consume 4½ cubic feet of gas per hour; the gas pressure being generally about 15 10ths; and lamps are spaced 40 yards apart on alternate sides of the street.

A number of lamps were converted a year or two ago into incandescents; "Block" fittings of the "Domestic" type being inserted in the old lanterns, burning 6 cubic feet per hour.

The arc lamps are of the ordinary open type, erected on poles, 22 feet high and 80 yards apart, on alternate sides of the street.

At a distance of 12 feet above the street, two incandescent lamps are fixed on brackets to the lamp column; the arc lamps being turned off at 11.30. For the remainder of the lighting hours, the incandescents are burning.

As to whether gas lighting by means of incandescent lamps is more efficient for the same money than electric lighting, the opinion of the borough engineers is almost in every case in favour of gas lighting. Much, however, will depend on the respective prices of gas and electricity and other local conditions.

There does not appear to be any general type of burner which has been found quite satisfactory; but the "Kern" and the "Welsbach" appeared to be most favoured. But these are becoming somewhat out of date owing to the introduction of improved inverted types; and the author is favourably inclined to the "Dacolight" inverted regenerative lamp.

One reason why the question of street lighting has not been dealt with before is that in this particularly stormy town, owing to the old lanterns not being wind-proof, the wind plays havoc with the mantles; and there is a difference of opinion as to whether an up-to-date type of burner should be fixed in the existing lanterns, or an entirely new lamp obtained.

As regards the respective merits of the various descriptions of lamps, in Barrow copious photometric readings have been taken in the streets at various times; but the author places little practical value on such tests. From a practical test which has been taken they might roughly be classified as follows: Taking the flat flame as 1, then the 6-feet incandescents represent 2¾, and the 10-ampère arcs 6; the cost being as follows: Flat flame, £2 5s. 8d. per annum; 6-feet incandescents, £3 8s. 3d.; 10-ampère arcs, £17 10s.

We have now under observation various types of lamps for street lighting, including a 400-candle power metallic filament incandescent electric lamp.

Regarding the water supply of the town, Mr. Race said: Water is supplied by the Corporation, and, with the exception of the Duddon scheme, from impounding reservoirs of the ordinary type formed by an embankment across a natural valley. The total extent of the catchment area for the Poaka Beck, Pennington, and Harlock reservoirs is 1980 acres; and the average annual rainfall for this area is 58 inches. The drainage area above the intake for the Duddon supply is no less than 12,000 acres, and has an estimated yield of 47 million gallons per day during the three driest consecutive years; the average rainfall being about 90 inches annually.

The following statement gives the capacity of the several reservoirs.

Name of Reservoir.	Completed.	Area in Acres.	Height Above O.D.	Greatest Depth.	Contents in Gallons.
			Feet.	Ft. In.	
Ireleth	..	1·90	402	22 0	3,600,000
Poaka Beck	..	28·75	505	44 8	190,300,000
Pennington	1879	22·50	505	37 8	140,700,000
Harlock	1896	30·00	610	57 0	226,800,000
Seathwaite (compensation reservoir)	1907	90·00	1230	80 0	680,000,000

By the scheme recently completed, the Corporation take from the River Duddon (a small river about 30 miles long, dividing Cumberland from Lancashire) water under the following circumstances: When there are 3 million gallons per day passing the intake, which is about 7¾ miles from the source, by an arrangement of automatic sluices, the Corporation take all between that amount and 5 million gallons; and when 15 million gallons per day have passed the intake, they may take an additional 1 million per day. The Corporation, however, have to guarantee a minimum of 3 millions per day to pass down the stream; and in order to do this, the level of the outlet of the Seathwaite Tarn (about 4½ miles above the intake) was raised 20 feet by means of a concrete wall. A large compensation reservoir was thus formed.

The cost of the works at the intake, copper screens, settling tanks, sluices, &c., concrete dam to the compensation reservoir, 17⅛ miles of 22-inch cast-iron main, and high-service reservoir with a capacity of 2 million gallons at Barrow, was about £164,000.

The average consumption for manufacturing purposes is 11·80 gallons per head per day, and for domestic purposes 26·70 gallons. There are five service reservoirs, with a total capacity of 152 million gallons.

The management of the water-works is in the capable hands of Mr. W. Fergusson, who succeeded his father, the late Mr. W. Fergusson, as Gas and Water Works Manager, who held that position for 25 years—until 1903.

Owing to the heavy rains which have lately visited parts of Switzerland, the Lake of Zurich was in flood last week, with the result that the lighting in the lower parts of the city was affected.

ELECTRIC LIGHTING AT NEWPORT (MON.).

An Over-Capitalized Undertaking.

An inquiry was recently held at Newport (Mon.), by Mr. H. R. Hooper, M.Inst.C.E., one of the Inspectors of the Local Government Board, in respect of an application by the Corporation for sanction to borrow £31,255 for the purposes of their electricity undertaking.

The Town Clerk (Mr. A. A. Newman) attended in support of the application; Mr. L. H. Hornby represented the Newport Ratepayers' Association; and Mr. T. B. R. Wilson watched the proceedings on behalf of the Gas Company.

The Town Clerk gave particulars of the population, rating, and indebtedness of the borough, and said the amount of loans outstanding was £1,788,387. With regard to the application, the main reason for it was that the demand for electricity had overtaken the supply. For some time there had been no profit from the concern; so the Committee called in an expert—Mr. C. P. Sparks—whose principal suggestion was that the supply should be concentrated at the Corporation Road works, and that the bulk of the plant at the Llanarth Street works should be scrapped.

Mr. *H. Collings Bishop*, the Electrical Engineer, presented a statement dealing with the history of the undertaking, and said that Mr. Sparks, in his report, which it had been thought undesirable to publish, so as to be the subject of newspaper controversy, expressed the opinion that the undertaking was over-capitalized, and that any future expenditure must necessarily be of such a nature as to reduce the proportion of capital to output. The proposed scheme superseded plant to the amount of £7064, outstanding capital charges, and it was expected that about £3000 would be obtained by the sale of it. As regarded the financial side of the application, there was a loss of £1460 on the working in the year 1908-9. The Corporation had not any arc lamps in the public streets; and in the side streets, where electricity was being substituted for gas, no capital moneys had been expended. A proportion of the cost was paid by the Street Lighting Department, and the remainder was paid out of the current revenue of the Electricity Department. The total amount so charged against revenue for 1908-9 was £1425. Witness gave the results of the working of the undertaking for the year 1909-10, which have not yet been presented to the Electricity Committee. He said that the total units sold were 4,012,909—an increase on the previous year of 397,126 units. In 1908-9, the total revenue was £31,275; and for 1909-10 it was £35,328—an increase of £4053. In 1908-9, the total working costs were £14,867, and they rose in 1909-10 to £16,671, or £1804 more. The gross profits were: 1908-9, £16,406; 1909-10, £18,656; increase, £2250. The interest and sinking fund charges in 1908-9 amounted to £17,876, and last year to £18,281. In 1908-9, there was a loss of £1469; but this year there was a profit of £375 arising solely from increased demands for power. As regarded the current year, he estimated that with the increased lighting charges there would be a gross profit of £23,250, and a net one of £4069. Witness then gave details of the additional plant which will be put in at the Corporation Road station; and, in answer to questions by the Inspector, he said the total capital expenditure on the undertaking up to March 31 last was £278,836, and the amount realized £278,260—the overdraft of £576 being on various loans. The amount expended on mains and services up to date was £87,929.

The Inspector: We must see precisely where you stand in regard to excess expenditure before further moneys are borrowed. What do you propose to do in respect of the overdraft?

Witness: The matter is at present engaging the attention of the Committee.

The Inspector went at length into the sanctions for loans and the expenditure for several years back, and said it appeared that with the overdraft and the sum borrowed (but not expended) in excess of what had been spent, there was a suspense account of £2073 not yet dealt with. The reduction of the capital charges was going on at a very slow rate; so that it was advisable that the Corporation should not add to them more than was absolutely necessary. The interest and sinking fund charges were heavy. It was the capital charges that were killing the undertaking; for all their reduction of works costs would not amount to much unless their capital account was kept low. This was what Newport was suffering from—high capital charges. For every £100 of capital expended, only £75 was for labour and material; £25 being the moneylenders' interest.

The opposition to the application was then opened.

In answer to Mr. Wilson, witness said the amount applied for was nearly double that which Mr. Sparks recommended (£17,215); but he only dealt with a portion of the expenditure. The increased demand for electricity owing to public lighting was only trifling compared with that required for power purposes. They had since 1907 increased by 300 the number of street-lamps lit by electricity. The total expenditure for street lighting paid by the Electricity Department for 1910 was £425. This probably covered 200 lamps. About £4 per lamp was the cost of conversion; and a portion of it was paid by the Street Lighting Department. Any deficiency under this head came out of the revenue account of the department, and so, of course, out of the ratepayers' pockets. Answering further questions, witness said £3600 had up to date been expended out of capital account on street lighting; but he could not tell how much more had been charged to revenue. He could get the figures; but he objected to do so for the Gas Company.

Mr. Wilson said the Company were not there in any competitive spirit whatever; but they considered that the time had come when this question of public lighting should be brought to the attention of the Local Government Board.

In further cross-examination, witness said public lighting by electricity came to about the same as gas. The cost per lamp was about £16. In 1903, the Gas Company offered to light 144 lamps with Welsbach triple incandescent burners at £12 per lamp. This might represent a saving of £704; but he considered that more lamps would be required if gas were used instead of electricity.

Mr. Wilson put to witness certain figures which showed that while public lighting in 1892 cost £3026, in 1909 it cost £7049, or an increase

of 133 per cent.; and the number of inhabited houses rose from 8600 in 1892 to 13,819 in 1909, or 60 per cent.

Witness accepted the figures, but said there were now longer roads to light, while the lighting had been improved. Answering further questions, he said there were 1500 electricity consumers in the borough, on the mains of which £88,000 had been expended. He admitted that there had been a considerable loss on the Electricity Department, but denied that it would have been less had street lighting been left alone. The cost of production at present was 0·8d. per unit, and they were getting 1·25d. per unit for the street-lamps, which he considered was quite enough. The electricity works were rated at £1930, which he did not consider unduly low. The Gas Company were rated at £6600; and if the Electricity Department were rated on the same basis, they might have to pay £4400.

Mr. *Bishop*, cross-examined by Mr. HORNBY, went fully into the accounts of the Electricity Department for the present year, with the result that he showed that, owing to an arithmetical error, the net profits next March should be estimated at £2069 instead of £4069, as stated by the witness on the previous occasion. Thereupon he remarked that, regarded as an ordinary trading concern, the Electricity Department was next to bankruptcy. As the result of further questions, he put it to the witness that, even if all his anticipations as to increased revenue turned out to be correct, instead of there being a profit next March, there would be a loss of £3000. He submitted to the Inspector that this was the proper position of affairs.

The INSPECTOR: There is a debit of over £1030 on a suspense account for superseded plant; and the Council must know that this will have to be met before sanction can be given to a further loan. This appears to have been carried forward year by year since 1904. I see also there is a debit of £410 on public lighting account. I am afraid that, looking at the accounts plainly and straightforwardly, instead of a profit for 1909-10, there is a loss.

Mr. WILSON: This sum of £410 is repayable by the Lighting Committee in two instalments of £200, and so is not properly a charge against the revenue of the electricity undertaking.

In answer to the Inspector, witness explained that the work comprised putting up and fitting the street-lamps within the past few months, and the cost had been treated as a debt.

Mr. HORNBY addressed the Inspector. He said he was present on behalf of the Ratepayers' Association to protest, as they had done before, against the way in which the accounts of the different undertakings of the borough were kept. Those whom he represented contended that all the accounts should be under the control of the Borough Treasurer; whereas no books of the tramways or the electricity undertaking were inspected by him. The Electricity Committee were in the position of being buyers and sellers. They supplied electricity to themselves for public lighting and for tramways purposes, and the slightest manipulation of the accounts would suffice to show a profit for either one or the other department. As things stood at present, on the Engineer's own estimates, there would be a loss next year on the Electricity Department of at least £800—perhaps £3000. This was a very serious matter; and the Association he represented felt very strongly that the Local Government Board should not allow the Corporation to do more with their already heavy capital on this undertaking than provide for their immediate necessities.

Mr. WILSON followed. He laid stress upon the fact that while Mr. Sparks only recommended an expenditure of £17,000, the Corporation were now applying for sanction to a loan of £31,255. Like the Ratepayers' Association, the Gas Company called attention to the way in which the Corporation accounts were being kept. Apart from these two points, except for the question of public lighting, the Company would not have been there at all. They were not there because they desired to get any advantage as a competitive body, but because they were practically the only persons in the town outside the Corporation who knew the facts with regard to the public lighting. They strongly repudiated the idea that they objected to the Corporation having facilities for competing with them; but they asserted that the public lighting could have been done by gas for considerably less than it was being done by electricity. The Gas Company offered to undertake the public lighting at £12 per lamp; but the Council adopted the electric light at £16 per lamp. This represented a difference of from £600 to £800 per year. In addition to this, there was the cost of the erection of the lamps and their conversion; and he believed that nothing was charged in respect of management expenses. Altogether, the Council had lost for the last seven years in respect of public lighting from £800 to £1000 per annum. One unique advantage the electricity undertaking enjoyed was in respect to its rating. Though they had a capital expenditure of £278,000, they were only rated at £1930; while the Gas Company, with a capital of £343,949, were rated at £6769. If the electricity undertaking had been assessed on the same basis, it would have been rated at £15,283. This at 7s. 8d. in the pound, the total rates, would have meant an additional charge of £1265 per annum. In conclusion, he said the Gas Company only desired fair and honest competition with the Corporation.

The TOWN CLERK, replying to the speeches for the opposition, said it seemed an extraordinary argument on the part of any ratepayer that the electricity undertaking was not rated high enough. They had heard a good deal about this poor "bankrupt" concern, and one could not help but feel that the undertaking was being harassed rather than assisted by those appearing in opposition. He thought the Inspector would be satisfied that, as regarded the public lighting, it had been a profitable business for the Corporation, and that they were justified in doing what they had done.

The inquiry then concluded.

The Fire at the Saltley Gas-Works.—We learn that a report has been presented to the Gas Committee of the Birmingham Corporation in regard to the recent tar-tank fire at Saltley Gas-Works (see *ante*, p. 645). It appears that the outbreak was due to the disobedience of a workman in using a fire-bucket; and he has been punished by being discharged.

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USE OF TAR FOR ROAD SURFACES.

Value of Storage—Effect on Fish Life.

On the occasion of the recent meeting of the Royal Sanitary Institute at Hereford, a paper on "Road Tarring in Districts of Small Rateable Value" was read by Mr. R. G. Gurney, the Surveyor to the Ledbury Urban and Rural District Councils. In the course of it, he made the following remarks.

It appears to be generally accepted that for tar painting to be a success it is essential that the road must have a rigid foundation; but this may just as well be said with reference to macadam or any other roads. My experience shows that an ordinary macadamized road will very soon crack and break-up during dry weather under engine and motor traffic if the foundation is not fairly strong; but if bound with tar the weak foundation will be protected and kept dry, and the tar will keep the surface down better than any known remedy. I have noticed, too, that a tar-painted surface will recover considerably more quickly if shaken by engine traffic than a water-bound road.

Tar undoubtedly has no wearing properties in itself, but it has the happy knack of prolonging the life of road metal to its utmost; and one has only to motor fast over a road that has been "darned" (say) twelve months before with tarred stone to feel how the tarred portions project from the surface after the ordinary macadam is worn down.

My experience is that the quality of tar varies considerably at different gas-works—attributable possibly to the coal used, or to the heat of the retorts when the tar is distilled. But, in any case, it should be stored in a fairly deep tank or well, to allow the ammoniacal liquor and lighter oils to separate and rise to the top, and the tar should then be pumped or drawn from the bottom. Our local gas companies have come forward and put in additional tanks to assist us; and one of my authorities has entered into a three years' contract to take all tar made at from 20s. to 25s. per ton of 200 gallons.

One reads so many times of damage to trees and fish, to say nothing of cows, from tar-painted roads, that I feel justified in mentioning one or two facts. Some two years ago, while excavating an old gravel path for converting into a tar-paved surface, the thousands of small roots from a great vine on the house adjoining were exposed, and the tarred path was placed 4 inches thick directly on them. The vine continues to flourish with not the slightest ill-results. Last year my Rural District Council decided to tar-paint about a mile of road immediately adjoining a celebrated trout stream. Notice was given by the landowner that the Council would be held responsible for any fish that might be killed; but it was decided to risk it. Just as the work was completed, a terrific thunderstorm came on, bringing the river into flood; and the newly-tarred road was flooded to a depth of 4 inches. I spent rather a restless night, and made quite an early inspection of the stream next morning, with the ostensible object of finding dead fish. I searched the stream high and low, but could not find a dead fish, nor was there the least trace of tar-stained water. The cause of this I put down to the fact that the tar had been well boiled, and was applied at boiling-point, so that all the ammoniacal liquor and the more soluble bodies had been boiled out.

In connection with the latter remarks of Mr. Gurney, it may be of interest to reproduce from the "Daily Mail" of Tuesday last the following letter from Mr. A. J. Belcher, of Wantage: "While I was fishing in a trout stream close to this town last Thursday, a heavy thunderstorm came on, and in a few minutes hundreds of trout came to the surface of the water and died immediately. The local authorities were tar-spraying the roads at the time, and the tar was conveyed into the brook by a storm overflow-pipe. I am absolutely certain as to the cause, as there was not a fish killed above where the pipe discharged. This wholesale destruction can be avoided to a great extent if the tar is put down in fine weather, because when it is once set it does not wash off. As a proof of this, there was a heavier storm on Tuesday evening; but most of our streets were tarred the previous Friday and Saturday, and had got hard. I cannot trace a single fish being killed on this occasion. By the use of a little discretion, a great number of fish may be preserved that will otherwise be destroyed."

GAS COMPANIES AND IRONMONGERS.

The following remarks appeared in the "Ironmonger" on Saturday.

The President of the Institution of Gas Engineers touched upon a tender spot in his address to the members assembled in annual meeting this week in London. The problem always before the eyes of managers was how to dispose of 1000 cubic feet of gas at a reasonable profit. It was now even more important than the consideration of the most economical way in which that quantity of gas could be produced. Gas companies had now, more than ever, become shopkeepers; and the work which was in the old days principally confined to ironmongers had to a large extent drifted into the show-rooms and workshops of gas companies. Was it wonderful that ironmongers should, as a rule, even now fail to appreciate the significance of the change which had taken place, when it must be acknowledged gas companies themselves had but lately learnt the lesson? Mr. Helps gave it as his opinion that the terms upon which gas companies undertook work for consumers and supplied them with apparatus and material might well, with no loss to themselves, be such as would allow any ironmonger or local tradesman who was wise enough to qualify his staff for this particular class of business to compete with a reasonable chance of profit. An exception to this principle might have to be made with regard to the maintenance of incandescent burners. In order to secure satisfaction to their consumers, gas companies must do this work on unremunerative terms, at least to the extent of giving labour free and charging only at a reasonable profit for all material used. Coming from a man occupying the

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position which Mr. Helps does, these opinions merit special attention. They confirm the view that the ebb-tide in the prices of gas stoves and cookers has turned, and that the spade work and educational policy of the companies, so far as they affect the public, have been accomplished; and they afford a hint that a time is coming when gas stoves, cookers, and fittings will have to carry their share of the expense burden and contribute to the profits. When that day arrives, the ironmongers may come into their own again.

GAS COAL POSITION IN THE MIDLANDS.

Dealing with the above-named subject last Friday, the "Iron and Coal Trades Review" made the following remarks: "Usually by this time the bulk of the business in regard to renewals of gas coal contracts has been arranged; but this year the reverse state of affairs exists. This position has largely been brought about by the increased membership of the Gas Coalowners' Association, which formerly was mostly composed of South Yorkshire collieries, but this year includes, with only a few exceptions, all the large gas-coal producing collieries in the Midlands, and it is understood that the few outside the Association will, so far as they can, work along with it. In the past there is no doubt gas coals have been sold at prices far below what would have been realized on the house coal market, and in many instances at a distinct loss to the producers, owing to the excessive competition for business, especially in the case of the large tonnage orders. The inclusion in the Association of all the large producers is to be commended, so long as no attempt is made to put values at an artificial level. It is certainly only by some combination among owners that the ruinous price-cutting policy pursued in recent years can be overcome. The agreement of the Association is that on all contracts at inland works the terms of renewal shall be 9d. per ton advance on last year's price; and at present this is generally strictly adhered to. Hence the reason for the small number of contracts renewed, buyers holding back in the hope of securing better terms. Some few contracts have been renewed at 6d. per ton advance; but these are where a smaller reduction was effected last year. Apparently it was a big mistake to give any reductions last year, especially in view of the fact that the increased cost of working under the conditions of the Eight Hours Act had not been properly tested; and it is safe to say that, had there been an Owners' Association, including the large producers as it does to-day, there would have been no real necessity to give any reductions. Early in the season it was hoped there would be a large tonnage placed in the Midlands by the London water-side gas companies, on account of the proportionate increased prices quoted by Durham collieries, who have since accepted lower rates, and which would have very considerably strengthened the sellers' position. Instead of this, however, the purchase of German coals by the London water-side companies will indirectly tend to more competition against the Midlands in regard to shipment coals."

NOTES FROM SCOTLAND.

From Our Own Correspondent.

Saturday.

The report of the Gas Manager—Mr. A. C. Young—for the year ending May 15 was submitted to the Arbroath Town Council on Monday. In it, Mr. Young stated that the gas manufactured amounted to 98,513,400 cubic feet, an increase of 847,700 feet over the previous year; and that the gas made per ton of coal used was 9679 cubic feet, a decrease of 173 feet. The quantity of gas sold was 92,088,332 cubic feet—an increase of 1,206,685 cubic feet. The quantity sold to ordinary consumers was 58,820,032 cubic feet—a decrease of 1,786,855 cubic feet; and the quantity sold to prepayment gas-meter consumers was 30,278,400 cubic feet—an increase of 3,414,650 cubic feet. The total revenue from the sale of gas was £13,087—a decrease of £698. The number of prepayment meters now in use is 3129—an increase of 249; and the number of ordinary and prepayment meters in use is 6359—an increase of 40. The number of cookers, grillers, and rings now fixed to consumers is 4346—an increase of 343. In addition, there are 68 gas-radiators hired to consumers; and 48 gas-fires for heating rooms were sold during the year. The cost of the new gasholder, including the concrete foundations, pipes, and connections, amounted to £5651; and the cost of the new condensers, £489, together with £728 paid for the ground for the site of the holder, had been placed against the suspense account, which now stands at £6868. The new condensers had given satisfaction, and had come fully up to expectation; and the new holder had worked well, and had done most of the work of supplying the town with gas during the winter. It had stood the severe test of gales much better than the old type of standard guided holders, and had proved in every way dependable. The Gas Committee adopted the report of the Manager, and agreed that the price of gas should remain at 2s. 8½d. per 1000 cubic feet, with a rebate of 2½d. per 1000 cubic feet for gas used in engines up to 250,000 cubic feet, and of 5d. for gas-engine consumption above this figure; also that the rate for gas through prepayment meters should be 3s. 1½d. per 1000 cubic feet. A year ago, the price of gas was reduced by 2½d. per 1000 cubic feet. Bailie Smith, the Convener of the Gas Committee, moved approval of the minutes. He said they heard it stated that, although the price of gas was reduced, the bills remained the same as previously. During the past year, they had sold 92 million cubic feet, and had drawn less money than before. This proved conclusively that consumers in Arbroath were getting the benefit of the low price of gas. They expected to be able to pay £2000 of the cost of the new gasholder, and to place another £100 to the insurance fund started three years ago, bringing it up to £700. The economies they had been able to practise had enabled them to pay the interest on cost of the new holder. The minutes were approved.

The make of gas in Dunfermline during the past year was 134,823,000 cubic feet—an increase upon the previous year of 8,076,000 cubic feet, equal to 6·37 per cent. Gas accounted for amounted to 125,959,900

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cubic feet—an increase of 8,841,500 cubic feet, equal to 8·47 per cent. The estimates prepared by the Gas Engineer—Mr. A. Waddell—for the current year provided for a reduction in the price of gas by 3d. per 1000 cubic feet. Mr. T. Stewart, the Convener of the Gas Committee, in moving adoption of the minutes of the Committee, said it was matter for congratulation that the community might look forward to further benefits from the Gas Department. Last year's working had been what might be called a phenomenal success. He had no hesitation in saying that, with normal conditions as to the price of coal, they might look forward to a further substantial decrease in the price of gas. He did not think that when ex-Provost Walker took this matter in hand, he ever anticipated that in 1910 the Corporation would be able to offer gas for ordinary lighting at 2s. 3d. per 1000 cubic feet, and for power at 1s. 6d. It showed that a generous policy paid in the end. They paid £6000 or £7000 for coal, and received over £5000 for residuals. The standing charges against the works were 9¾d. per 1000 cubic feet of gas sold; so that what was left for the making of gas was only the difference between 2s. 3d. and 9¾d. They would see from this how necessary it was for the works to keep up the output. Happily the output was increasing. A penny per 1000 cubic feet represented a sum of £542; so that the present reduction of 3d. benefited the community to the extent of £1626. Last year consumers were relieved of meter-rents and stove hires; and this was equivalent to another penny per 1000 cubic feet, or, altogether, £2100. He had it in his mind to ask the Council to again extend their confidence to the Committee, by authorizing them to spend a considerable sum in erecting vertical retorts. Mr. Waddell had just about exhausted his inquiries regarding the benefit these would be to the gas-works; and it was now a question as to what particular sort of retorts should be adopted. A considerable saving would be effected in the manufacture of gas, and the value of residuals would be greatly increased; and, altogether, the proposal would give a distinct benefit to the community. There was a proposal to supply Torryburn with gas. There was no doubt that in the near future a large population would spring up in the Torryburn district; and he thought it might be looked upon as a certainty that if the Corporation did not step in, a private company would be formed immediately to supply the wants of the rising community. When Mr. Waddell prepared his estimates for the Limekilns and Charlestown scheme, he calculated upon a probable consumption of 2,245,000 feet during the second year. The actual consumption was 2,270,000; so that the undertaking was practically a paying concern. Mr. Waddell had estimated that 217 meters would be required; and the actual number was 240, exclusive of stoves. Dean of Guild Hoey pointed out that when Mr. Waddell entered their service, ten years ago, the price of gas was 3s. 11d. per 1000 cubic feet; it was now 2s. 3d. The amount of money involved annually by this reduction was possibly £10,000 or £11,000. Besides, they had paid off £25,000 or £26,000 of capital, improved the works, and improved the distributing system throughout the town. The consummate skill of the Manager, and the efficient supervision he brought to bear on his work, reflected the highest credit upon him; and he deserved the thanks of the Council for what he had done during the period that he had held the position of Manager. The recommendations of the Committee were adopted; and the prices of gas were fixed at 2s. 3d. per 1000 cubic feet for ordinary and public lighting, 2s. 9d. for prepayment consumers in the town, 1s. 6d. for gas-engines, and 4s. 3d. in the districts of Limekilns and Charlestown.

The Pitlochry New Gaslight Company have just declared and paid a dividend of 3 per cent.

In the Kirkintilloch Town Council this week, Mr. W. Alexander, the Convener of the Gas Committee, stated that in the Gas Department the financial year began with a slight debit balance, and they were likely to close with a credit balance of over £1000. Among matters to which consideration would be given by the Committee were the abolition of meter-rents and a proposal to do away with the hire of gas-cookers. They wanted the consumption of gas increased; and the giving of gas-rings free last year was one of the best things the Council ever did. They would also consider the question of reducing the price of gas.

In the Hamilton Town Council this week, the Gas Committee reported that the Gas Manager's minute to them, containing the prices of coal during the past two years, showed a saving of at least 7d. per ton on the coal to be delivered at the railway siding this year.

The salaries of Mr. A. Smith, Mr. A. M'Leod, and Mr. J. Webster, the Engineers-in-Charge of the Tradeston, Dawsholm, and Provan gas-works of the Glasgow Corporation, have each been increased by £50 per annum.

In the "Scotsman" of yesterday, there appeared the following: "For some considerable time, the gas and burgh officials of Bo'ness have been concerned about escapes of gas on the roadway opposite Cadzow Crescent and Mount Pleasant. In an attempt to remedy matters, the Gas Company, at considerable expense, laid a new main from Craigmailen United Free Church to Dundas Street. No improvement has resulted; and a suggested service-pipe to dwelling houses at Mount Pleasant was subsequently renewed. While testing this pipe, the gas officials were alarmed by the whole track bursting into flame. It was then discovered that the flame resulted from an escape of natural gas from the minerals at that part. Mr. H. M. Cadell, of New Grange, applied one or two simple scientific tests, and corroborated the impressions formed by the officials on the ground. Mr. Cadell states that some time ago a mysterious outbreak of fire occurred at one of the houses at Mount Pleasant, and on quite a reasonable theory it was caused by this natural gas finding its way into the dwelling house from the ground. Experiments were made with a steel tube, which was driven into the ground, and a light was obtained therefrom, which might be burning 50 cubic feet per hour. The monetary value of the gas was considerable, and it is quite possible to accumulate and utilize it. It has been arranged that a perforated tube will be inserted, and a pipe led into a small tank, from which the gas can be conducted to a lamp-pillar at the foot of Cadzow Crescent, and burned off."

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LEST YE FORGET.

CURRENT SALES OF GAS PRODUCTS.

LIVERPOOL, *June* 18.

Sulphate of Ammonia.

Although the market has been quiet, there has been a steady demand all through the week, and prices have been about maintained at £11 16s. 3d. per ton f.o.b. Hull, £11 17s. 6d. per ton f.o.b. Liverpool, and £11 18s. 9d. per ton f.o.b. Leith. Although there continues to be inquiry in the forward position, the firmer attitude of makers, after sales made last week, has deterred buyers, and no further important transactions have been reported.

Nitrate of Soda.

The market on spot Liverpool is easier, and quotations are 9s. 4½d. per cwt. for 95 per cent., and 9s. 7½d. for refined quality.

LONDON, *June* 20.

Tar Products.

Pitch has remained steady during the past week. Benzols have fallen to the extent of 1d. per gallon, and considerable business has been done at the reduced figures. Crude carbolic acid is still of very little interest, and dealings are almost impossible. Creosote remains steady, and further business is reported at present prices.

The average values during the week were: **Tar**, 17s. 9d. to 21s. 9d., *ex* works. **Pitch, London**, 40s. to 40s. 6d.; **east coast**, 38s. 6d. to 39s. 6d., **west coast**, 37s. 6d. to 38s. 6d. f.a.s. Mersey ports. **Benzol**, 90 per cent., casks included, London, 7⅜d.; North, 7¼d.; 50-90 per cent., casks included, London, 8d.; North, 7⅜d. **Toluol**, casks included, London, 10d.; North, 9⅜d. to 10d. **Crude naphtha**, in bulk, London, 3⅜d. to 4d.; North, 3⅛d. to 3¼d.; **solvent naphtha**, casks included, London, 1s. 3d. to 1s. 4d.; North, 1s. 3d. to 1s. 4d.; **heavy naphtha**, casks included, London, 1s. to 1s. 1d.; North, 11d. to 1s. **Creosote**, in bulk, London, 2½d. to 2⅝d.; North, 2d. to 2¼d. **Heavy oils**, in bulk, 2⅜d. to 2⅝d. **Carbolic acid**, 60 per cent., casks included, east coast, 11½d. to 1s.; west coast, 11½d. to 1s. **Naphthalene**, £4 10s. to £8 10s.; salts, 40s. to 42s. 6d., bags included. **Anthracene**, "A" quality, 1½d. per unit, packages included and delivered.

Sulphate of Ammonia.

This article is quiet; and the inquiries of last week did not lead to any definite business. To-day, actual Beckton is quoted at £11 18s. 9d.; and for outside makes, upon Beckton terms, £11 10s. is asked. In Hull, £11 13s. 9d. to £11 15s. is the price; in Liverpool, £11 15s. to £11 16s. 3d.; and in Leith, £11 17s. 6d.

Messrs. F. C. Sugden and Co., of Leeds, have had orders placed with them by the Waltham Abbey and Cheshunt Gas Company, the Hoddesdon Gas Company, Limited, and the Bollington Urban District Council for settings of the Klönne regenerative type, with the Hudson patent producer. The first is a repeat order.

COAL TRADE REPORTS.

Northern Coal Trade.

The coal trade of the north-east has been languid of late, and the prices have shown some ease, more especially for steam coals. Best Northumbrian steams have been in fair delivery; but new business has been very slow, and the prices are lower—the current quotation being from 10s. to 10s. 3d. per ton f.o.b.. Second-class steams are about 9s. 6d. per ton; and best steams from 5s. 9d. to 6s. 9d.—the demand for the latter being fairly good. In the gas coal trade, the local consumption is now at its lowest point; but the exports are full. Durham gas coals vary from 9s. 4d. to 10s. per ton f.o.b. for the usual classes, according to quality; while for Wear specials, from 10s. 6d. to 10s. 9d. is quoted. In contracts there is not so much doing. But it is believed that part of the supply for Berlin has been placed; and the statement points to prices as sufficient to leave, after the deduction of freight, &c., from 9s. 4d. to 9s. 6d. per ton for good Durham gas coals. Coke is quiet; but gas coke is in limited supply, and may be quoted at from about 12s. 9d. to 13s. 3d. per ton f.o.b. in the Tyne.

Scotch Coal Trade.

Trade continues much as it was. Ell is in fair request. Splint is showing signs of improvement in demand. Steam coal is plentiful. Small sorts are finding a ready market. The prices now quoted are: Ell, 9s. 3d. to 10s. 3d. per ton f.o.b. Glasgow; splint, 10s. to 10s. 3d.; and steam, 9s. to 9s. 3d. The shipments for the week amounted to 311,127 tons—a decrease of 48,281 tons upon the preceding week, and of 11,135 tons upon the corresponding week of last year. For the year to date, the total shipments have been 6,937,804 tons—an increase of 674,645 tons upon the corresponding period.

The Question of Books at Carlisle.—In the "JOURNAL" for the 31st ult. (p. 581), reference was made to some critical remarks by Mr. Eggleston, in the Carlisle Town Council, as to the necessity and utility of certain books in use in connection with the gas and electricity undertakings of the Corporation; and some serious charges were brought against the Gas Engineer (Mr. Harold Bloor). The charges were considered by the Committees of both undertakings, and they each passed the following resolution: "That the Committee, having fully inquired into and investigated the charges made by Mr. Eggleston, are satisfied that the same are untrue and without foundation in fact; and that the Council be recommended to call upon Mr. Eggleston to either substantiate the truth of such charges or unreservedly withdraw the same." The matter was the subject of a long discussion at the meeting of the Town Council last Tuesday, when Mr. Eggleston withdrew the charges, and expressed regret that he had used excessively strong language. The result is that the minutes of the two Committees relating to the subject, with the resolutions and the reports of the Engineers thereon, will be expunged.

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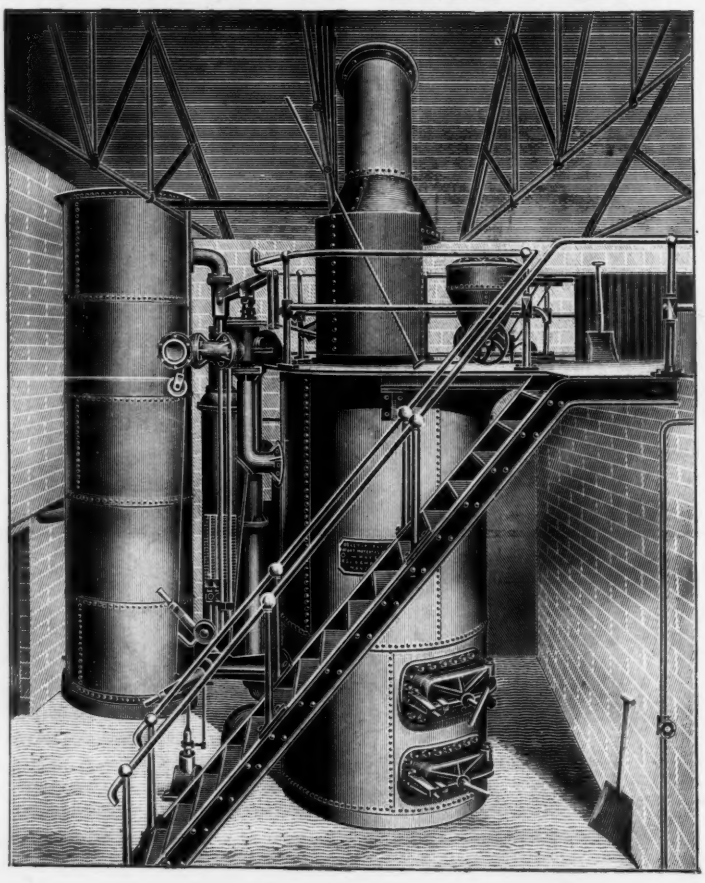

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Sales of Stocks and Shares.

At the Mart, Tokenhouse Yard, E.C., last Tuesday, Messrs. A. & W. Richards offered for sale by auction, by order of Directors, new issues of gas and water capital; and they were all taken up. The first lots consisted of £5000 of the ordinary stock of the Guildford Gas Company, ranking for a standard dividend of 5 per cent. per annum, subject to the sliding-scale; the existing similar stock having for some time received 5¾ per cent. It was all sold at £117 to £118 10s. per £100; £2500 of 4 per cent. perpetual debenture stock of the Company fetching from par to £100 10s. Some additional 7 per cent. stock of the Brentwood Gas Company, similar to that on which £6 6s. per cent., free of income-tax, has been paid, realized £131 to £133 10s. per £100. A small parcel of £10 new ordinary 7 per cent. shares in the Ascot District Gas and Electricity Company (similar shares carrying 5½ per cent.) fetched from par to £10 5s. each. Some £10 "C" shares and £1000 of 4 per cent. perpetual debenture stock of the East Grinstead Gas and Water Company were the last lots offered. The shares rank for maximum dividend of 7 per cent.; but £6 6s. per cent. per annum, free of income-tax, has been paid on similar shares for the last seven years. They were sold at from £12 7s. 6d. to £12 12s. 6d. each; the debenture stock being placed at par. A few days previously, Mr. W. A. Iveson (Messrs. W. & T. T. Iveson) sold at the Royal Hotel, Hexham, £2000 of ordinary stock of the Hexham Gas Company. The dividend payable on similar stock is at the rate of 5½ per cent. per annum. It was offered in £100 and £50 lots. The former fetched £110 and £111 and the latter from £55 to £55 10s. apiece.

Withdrawal of the Staffordshire Potteries Water Bill.—As will be seen from our "Parliamentary Intelligence," the Bill promoted by the Staffordshire Potteries Water Company has been withdrawn. This has been done owing, it is stated, to the opposition of the Council of the County Borough of Stoke-on-Trent. It appears that the principal object of the opposition was to get clauses inserted in the Bill to facilitate the purchase of the undertaking should the Council decide to do so at some future time; and it was also proposed to deal with the Company's charges for water.

Projected Extensions at the Mansfield Gas-Works.—In presenting certain recommendations of the Gas Committee at the last monthly meeting of the Mansfield Town Council, Mr. Smith referred to the proposed extensions at the gas-works, and said the Committee had decided it was imperative that they should be put in hand immediately. The gas-works at present was operating at high pressure, and if the work was not put in hand at once the necessary extensions would not be finished by November, in which case the town might be placed in an awkward predicament for a supply of gas. The Local Government Board had been made acquainted with the urgency of the matter, and the necessity for their sanction being given as early as possible for the work to be commenced; but as yet no reply had been received to the Council's application.

Natural Gas and Oil in New Brunswick.—The "Board of Trade Journal" announces that the Imperial trade correspondent at St. John, New Brunswick (Mr. W. E. Anderson), reports that deposits of natural gas and oil have recently been discovered in Albert County, New Brunswick. Three layers of oil sands have been encountered, one at 1100 feet, another at 1320 feet, and the third at 1742 feet. The last layer is 158 feet thick. At 1050 feet rich gas-producing sands have been struck. One well produces between 200,000 and 300,000 cubic feet of gas daily from the upper layer of sand, and another nearly a million cubic feet per day.

The Recent Appointment of Gas Receiverships.—The "Financial News" last Friday drew attention to the fact that quite a series of disasters to gas and water companies has been experienced within the comparatively recent past, as shown by the appointment of Receivers in the cases of the following Companies: East Sussex, Mid Oxfordshire, Rawcliffe, Robertsbridge (practically a non-existent concern), South Luton, and Ticehurst. Our contemporary remarked: "It is not often that so persistent a run of ill-luck attends one class of enterprise. The details will be the more interesting because we are apparently on the eve of further efforts to place the capital of small gas companies."

Projected Improved Public Lighting in Fulham.—The Lighting Committee of the Fulham Borough Council have received a communication from the Chief Inspector of the Gaslight and Coke Company, suggesting that improved efficiency might be obtained and economy effected by the substitution of inverted for upright incandescent burners in the public lamps, and asking for an opportunity of demonstrating this. The Committee have consented to the fixing of six single-burner inverted lamps on Parson's Green. The experiment will be carried out entirely by the Company, and at their expense; and should the results prove thoroughly satisfactory, a scheme for the conversion of all the existing gas-lamps will be submitted for the consideration of the Committee.

Artesian Wells in London.—Dr. Collingridge, the Medical Officer of Health for the City of London, has furnished the Corporation with a report on artesian wells in the City, of which there has been a considerable increase, owing to the revised charges of the Metropolitan Water Board. Fourteen artesian wells were sunk between 1836 and 1907, and 22 between 1907 and the present time; making a total of 36. The Public Analyst reported that the waters were highly pure and soft, but somewhat saline. A large West End hotel, paying £900 a year water-rate, installed an artesian well at a cost of £800; and the total cost of running it is £200 a year. Thus an annual saving of £700 has been effected at an expenditure of £800. If, however, the yield of water later on proves insufficient for the intended service, the Water Board's supply will have to be laid on to the premises and the money sunk in the well written off as a loss. In the City alone there are 36 wells in use, all supplied from the same source. The water being very soft is better suited for domestic and manufacturing purposes than that delivered by the Board.

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Devonport Corporation Water Undertaking.

The detailed accounts of the water undertaking of the Devonport Corporation, issued by the Borough Treasurer (Mr. H. J. Hoare), show that it is progressing in a very satisfactory manner. The transfer of the works to the Corporation took place on July 1, 1906; and at that time the number of houses supplied was 8605. In the year ending March 31 last, the supplies numbered 9226; the population having augmented in the meantime by about 4000. The average daily supply has increased still more—the total quantity having been 2,261,360 gallons in 1906, and 2,927,082 gallons last year; the growth being from an average of 32·30 gallons to 39·55 gallons per head per day. Most of this increase is in the domestic consumption, which has advanced from 19·68 gallons to 26·34 gallons per head. Six miles of new mains have been laid in the past four years; bringing up the total length to 66½ miles. On the financial side, the period has been one of heavy capital expenditure. The purchase of the undertaking cost £252,018, and in addition there was a sum of £4327 in parliamentary costs, and also a mortgage debt of £28,250 of the Water Company which the Corporation took over. Since then they have been engaged in improving and extending the works, and have spent £41,679 in this way. The capital has thus advanced from £282,383 in 1906 to £321,947 on March 31 last. In the past year the revenue was £21,283, of which £14,023 was for domestic supplies. The working expenses amounted to £6519; leaving a balance of £14,764 gross profit. Up to now, the Corporation have been practically free from the obligation to provide a sinking fund, and, with the exception of paying off the cost of obtaining the Act of Parliament, the chief liability they have had to meet on capital account has been the charges for interest, which amounted last year to £11,137. A net profit of £3265 was therefore made last year. This sum was carried to the reserve fund, which it is intended to draw upon when the payments to the sinking fund begin a year or two hence. The gross profit, it is pointed out, is equal to 4½ per cent. on the capital employed. Calculated on the basis of the number of houses supplied, income is equal to £2 6s. 2d. per house, the working expenses being 14s. 2d., and the capital charges £1 4s. 11d.; leaving a net profit for each house of 7s. 1d.

Additional Capital for the Newport (Mon.) Gas Company.—At the meeting of the Directors of this Company last Friday, tenders in respect of the issue of £16,000 of consolidated stock, which were invited in the "JOURNAL" a few weeks ago were opened, when the whole of the amount was taken up. The minimum fixed was £112 per £100 of stock, and the average price offered was £113.

Wolverhampton Water Supply.—According to the report of the Water Committee of the Wolverhampton Corporation, a profit of £4760 was earned in the past financial year, after payment of interest and sinking fund charges. A sum of £2834, which is equal to a rate of 2d. in the pound, has been appropriated in reduction of the improvement fund; and the balance (£1926) has been added to the reserve fund, which now stands at £11,878.

The accounts of the Tiverton Corporation gas undertaking, which have just been published, show that the year ended the 31st of March was the most profitable in its history. In 1896, after the gas-works had been under municipal management for twelve months, a gross profit of £1826 was shown. For the year just closed, the gross profit was £3089—an increase of £1263 in fifteen years. Compared with the year ended March 1909, the increase was £542; and the Lighting Committee have voted £400 for the relief of the rates. The turn-over of the Gas Department is nearly £9000 per annum. The capital invested in the gas-works is £32,240, of which more than half has been either repaid or put into the sinking fund out of profits. At the present rate of progress, the whole amount borrowed for capital will have been repaid in another 15 years.

APPLICATIONS FOR LETTERS PATENT.

13,680.—POLLOCK, C. V., "Gas-mixers." June 6.
13,685.—NON-EXPLOSIVE GAS COMPANY, LTD., "Manufacture of gas." June 6.
13,699.—GEWERKSCHAFT DES STEINKOHLEN-BERGWERKS LOTHRINGEN and FRIEDRICH UHDE, "Separation of ammonia from gases." June 6.
13,728.—EASTHOPE, E., "Gas-engines." June 7.
13,797.—DELAGE, M., and WOOG, P., "Electric lighting of gas-burners." June 7.
13,801.—CLOUDSLEY, J. L., JUN., "Two-stroke cycle internal-combustion engines." June 7.
13,825.—LAKE, H. W., "Compressing air or gas." A communication from H. A. Branch. June 7.
13,881.—KOEFOED, HAUBERG, MARSTRAND, and HELWEG AKTIESELSKABET TITAN and PETER GORM-PETERSEN, "Grabs for coal." June 8.
13,978.—BENNINGHOFF, O., "Cooling gas." June 9.
14,013.—ROELOFSEN, J. A., "Recovering ammonia from gas." June 9.
14,015.—HARDING, W. F. S., "Acetylene generators." June 9.
14,017.—STILL, W. M., AND SONS, LTD., and STILL, W. H., "Manufacture of mantles." June 9.
14,072.—GILL, A., and FOSTER AND FULLEN, LTD., "Lighting incandescent lamps." June 10.
14,074.—BRYAN, L. C., "Two-cycle internal-combustion engine." June 10.
14,084.—KENT-JOHNSTON, A. G., "Controlling the gas supply to lamps." June 10.
14,086.—SPARKS, E., "Lighting and extinguishing gas-jets." June 10.
14,100.—VIATOUR, C. G., "Suction gas-producers." June 10.
14,144.—WIGLEY, P., "Incandescent burners." June 11.

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Situations Vacant.

GAS MANAGER, Omagh Urban District Council. Applications by June 28.
ASSISTANT GAS MANAGER. No. 5256.
WORKS MANAGER. Apply to G. E. Woodford, Ruabon.
WORKING FOREMAN. No. 5255.

Plant (Second-Hand) for Sale.

GAS METERS. No. 5251.

Patent Licences.

REGENERATING COKE-OVENS. Haseltine, Lake, and Co., Southampton Buildings, W.C.

Stocks and Shares.

BARNET GAS AND WATER COMPANY. July 12.
BRENTFORD GAS COMPANY. June 28.
CHIGWELL, LOUGHTON, AND WOODFORD GAS COMPANY. June 28.
ILFORD GAS COMPANY. June 28.
PINNER GAS COMPANY. June 28.

TENDERS FOR

Coal and Cannel.

BELFAST GAS DEPARTMENT. Tenders by July 1.
EAST RETFORD GAS DEPARTMENT. Tenders by June 30.
FILEY URBAN DISTRICT COUNCIL. Tenders by June 27.
ILKESTON GAS DEPARTMENT. Tenders by July 6.
KESWICK GAS COMPANY. Tenders by June 23.
MANSFIELD GAS DEPARTMENT. Tenders by June 29.
NORTHWICH GAS COMPANY. Tenders by June 23.
RHONDDA GAS AND WATER DEPARTMENT. Tenders by June 30.
TEIGNMOUTH GAS DEPARTMENT. Tenders by July 4.

Coal and Coke Handling Plant.

WOMBWELL GAS AND WATER DEPARTMENT. Tenders by June 29.

Gasholder and Tanks.

EGREMONT URBAN DISTRICT COUNCIL.
OLDHAM GAS DEPARTMENT. Tenders by June 29.

General Stores (Lime, Sulphuric Acid, Castings, Lead Tubing, Rubber and Rubber Tubing, Yarns, Paints, Oil, Tallow, &c., &c.).

MANSFIELD GAS DEPARTMENT. Tenders by June 29.
KEIGHLEY GAS DEPARTMENT. Tenders by June 27.
SALFORD GAS DEPARTMENT. Tenders by June 30.

Meters, &c.

EGREMONT URBAN DISTRICT COUNCIL.
SALFORD GAS DEPARTMENT. Tenders by June 30.

Pendants, Brackets, Taps, &c.

SALFORD GAS DEPARTMENT. Tenders by June 30.

Pipes, &c.

KEIGHLEY GAS DEPARTMENT. Tenders by June 27.
RHONDDA GAS AND WATER DEPARTMENT. Tenders by June 30.
SALFORD GAS DEPARTMENT. Tenders by June 30.
SUTTON-IN-ASHFIELD GAS DEPARTMENT. Tenders by June 25.

Purifiers.

EGREMONT URBAN DISTRICT COUNCIL.
RHONDDA URBAN DISTRICT COUNCIL. Tenders by July 1.

Scrubber.

RHONDDA URBAN DISTRICT COUNCIL. Tenders by July 1.

Tank for Tar and Liquor.

RHONDDA URBAN DISTRICT COUNCIL. Tenders by July 1.

Tar and Liquor.

BRIERLEY HILL GAS COMPANY. Tenders by June 30.
CONGLETON GAS DEPARTMENT. Tenders by July 2.
FARNWORTH AND KEARSLEY GAS COMPANY. Tenders by June 29.
HEREFORD GAS DEPARTMENT. Tenders by June 25.
KESWICK GAS COMPANY. Tenders by June 23.
MANSFIELD GAS DEPARTMENT. Tenders by June 29.

NOTICES TO CORRESPONDENTS, ADVERTISERS, AND SUBSCRIBERS.

No notice can be taken of anonymous communications. Whatever is intended for insertion in the "JOURNAL" must be authenticated by the name and address of the writer; not necessarily for publication, but as a proof of good faith.

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Orders for Alterations in, or stoppages of, PERMANENT ADVERTISEMENTS should be received by the FIRST POST on SATURDAY.

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GAS COMPANIES' STOCK AND SHARE LIST.

Referred to on p. 775.

Issue.	Share.	When ex-Dividend.	Dividend or Dividend & Bonus.	NAME.	Closing Prices.	Rise or Fall in Wk.	Yield upon Investment.
£			p.c.				£ s. d.
1,474,000	Stk.	Apl 1	5	Alliance & Dublin Ord.	82 84	..	5 19 1
310,000	Stk.	Jan. 13	4	Do. 4 p.c. Deb.	100—102	..	3 18 5
200,000	5	May 12	7	Bombay, Ltd.	6⅛—6⅜	..	5 9 10
40,000	5	,,	7	Do. New, £4 paid	4⅛—5⅛	..	5 9 3
50,000	10	Feb. 25	15	Bourne-mouth Gas and Water } 10 p.c.	29—30	..	5 0 0
311,810	10	,,	7	Do. B 7 p.c.	16⅛—16⅜	..	4 3 7
75,000	10	,,	6	Do. Pref. 6 p.c.	15—15⅜	..	3 17 5
380,000	Stk.	,,	12½	Brentford Consolidated	251—254	..	4 18 5
300,000	,,	,,	9⅜	Do. New	188—190	..	5 0 0
50,000	,,	Aug. 12	5	Do. 5 p.c. Pref.	120—122	..	4 2 0
206,250	,,	June 10	4	Do. 4 p.c. Deb.	99—101*	..	3 19 3
220,000	Stk.	Mar. 16	11	Brighton & Hove Orig.	214—217	+1	5 1 5
246,320	,,	,,	8	Do. A Ord. Stk.	152—155	..	5 3 3
460,000	20	Apl. 1	10⅝	British	44—45	..	4 14 8
109,000	Stk.	Feb. 25	6	Bromley, A 5 p.c.	118—120	..	5 0 0
165,700	,,	,,	4½	Do. B 3½ p.c.	88—90	..	5 0 0
82,278	,,	,,	5½	Do. C 5 p.c.	105—107	..	5 2 10
55,000	,,	Dec. 29	3½	Do. 3½ p.c. Deb.	87—89	..	3 18 8
500,000	10	Oct. 14	7	Buenos Ayres (New) Ltd.	—	..	—
250,000	Stk.	Dec. 29	4	Do. 4 p.c. Deb.	98—100	..	4 0 0
100,000	10	—	—	Cape Town & Dis., Ltd.	3⅛—4⅛	−⅛	—
100,000	10	—	—	Do. 4½ p.c. Pref.	5⅜—6⅛	..	—
50,000	50	May 3	6	Do. 6 p.c. 1st Mort.	49 -50	..	6 0 0
100,000	Stk.	Dec. 29	4½	Do. 4½ p.c. Deb. Stk.	89 -91	..	4 18 11
157,150	Stk.	Feb. 25	5	Chester 5 p.c. Ord.	109—111	..	4 10 1
1,513,280	Stk.	Feb. 25	5⅛	Commercial 4 p.c. Stk.	107—109	..	4 15 5
560,000	,,	,,	5	Do. 3½ p.c. do.	103—105	..	4 15 3
475,000	,,	Dec. 29	3	Do. 3 p.c. Deb. Stk.	81—83	..	3 12 3
800 000	Stk.	June 10	5	Continental Union, Ltd.	95—97*	−1	5 3 1
200,000	,,	,,	7	Do. 7 p.c. Pref.	135—137*	..	5 2 2
491,270	Stk.	—	5½	Derby Con. Stk.	121—123	..	4 9 5
55,000	,,	—	4	Do. Deb. Stk.	104—105	..	3 16 2
145,995	,,	Apl. 1	5	East Hull 5 p.c. Ord.	96—98	..	5 2 0
486,090	10	Jan. 27	12	European, Ltd.	24⅛—24⅜	..	4 17 0
354,060	10	,,	12	Do. £7 10s. paid.	18⅜—18½	..	4 16 0
16,198,672	Stk.	Feb. 10	4⅜	Gas light and Coke } 4 p.c. Ord.	103⅛—104½	..	4 9 3
2,620,000	,,	,,	3½	3½ p.c. max.	88—90	..	3 17 9
4,002,235	,,	,,	4	4 p.c. Con. Pref.	104—106	..	3 15 6
4,531,706	,,	Dec. 29	3	3 p.c. Con. Deb.	81—83	..	3 12 3
258,740	Stk.	Mar. 16	5	Hastings & St. L. 3½ p.c.	93—95	..	5 5 3
82,500	,,	,,	6⅛	Do. do. 5 p.c.	117—119	..	5 9 3
70,000	10	Apl. 29	11	Hongkong & China, Ltd.	17—17⅛	..	6 5 9
131,030	Stk.	Mar. 16	7	Ilford A and C	145—147	..	4 15 3
65,783	,,	,,	5⅛	Do. B	108—110	..	5 0 0
65,500	,,	Dec. 29	4	Do. 4 p.c. Deb.	100 -102	..	3 18 5

Issue.	Share.	When ex-Dividend.	Dividend or Dividend & Bonus.	NAME.	Closing Prices.	Rise or Fall in Wk.	Yield upon Investment.
£			p.c.				£ s. d.
4,940,000	Stk.	May 12	8	Imperial Continental	177—179	..	4 9 5
1,235,000	Stk.	Feb 10	3½	Do. 3½ p.c. Deb. Red.	94—96	..	3 12 11
195,242	Stk.	Mar. 16	6	Lea Bridge Ord. 5 p.c.	122—124	..	4 16 9
561,000	Stk.	Feb. 25	10	Liverpool United A	219—221	..	4 10 6
718,100	,,	,,	7	Do. B	164—165	..	4 4 10
306,083	,,	Dec. 29	4	Do. Deb. Stk.	105—107	+1	3 14 9
75,000	5	Nov. 16	6	Malta & Mediterranean.	4⅜—5	..	6 0 0
560,000	100	Apl. 1	5	Met. of } 5 p.c. Deb.	100—102	..	4 18 0
250,000	100	,,	4½	Melbourne } 4½ p.c. Deb.	100—102	..	4 8 3
541,920	20	May 27	3½	Monte Video, Ltd.	12⅞—13	..	5 7 8
1,775,892	Stk.	Feb. 25	4⅜	Newc'tle & G'tesh'd Con.	103—104	+⅛	4 11
529,435	Stk.	Dec. 29	3½	Do. 3½ p.c. Deb.	91—93	..	3 15 3
55,940	10	Feb. 25	7	North Middlesex 7 p.c.	133⅜—133¾	..	5 1 10
300,000	Stk.	Apl. 29	8	Oriental, Ltd.	138—140	..	5 14 4
60,000	5	Apl. 1	8	Ottoman, Ltd.	6—6¼	..	6 8 0
31,800	53	Feb. 25	13	Portsea Island A.	134—136	..	5 1 0
60,000	50	,,	13	Do. B.	126—128	..	5 1 7
100,000	50	,,	12	Do. C.	119—121	..	4 19 2
114,800	50	,,	10	Do. D and E.	100—102	..	4 18 0
398,490	5	Apl. 29	7	Primitiva Ord.	7⅛—7⅜	..	4 13 4
796,980	5	Jan. 27	5	Do. 5 p.c. Pref.	5⅝—5⅞	+⅛	4 8 11
488,900	100	June 1	4	Do. 4 p.c. Deb.	97—99	..	4 0 10
1,000,000	10	Oct. 14	8	River Plate Ord.	—	..	—
312,650	Stk.	Dec. 29	4	Do. 4 p.c. Deb.	99—101	..	3 19 3
250,000	10	Apl. 1	9	San Paulo, Ltd.	15⅛—15½	..	5 14 3
62,500	10	,,	6	Do. 6 p.c. Pref.	11⅞—12⅛	..	4 18 0
125,000	50	Jan. 3	5	Do. 5 p.c. Deb.	50½—51½	..	4 17 1
135,000	Stk.	Mch. 16	10	Sheffield A	232—234	..	4 5 5
209,984	,,	,,	10	Do. B	232—234	..	4 5 5
523,500	,,	,,	10	Do. C	232—234	..	4 5 5
70,000	10	May 27	7	South African	11—11⅛	−⅛	6 1 9
6,429,895	Stk.	Feb. 10	5/9/4	South Met., 4 p.c. Ord.	120—122	..	4 9 7
1,895,445	,,	Jan. 13	3	Do. 3 p.c. Deb.	80—82	..	3 13 2
209,820	Stk.	Mar. 16	8	South Shields Con. Stk.	157—158	..	5 1 3
605,000	Stk.	Feb. 25	5⅝	S'th Suburb'n Ord. 5 p.c.	121—123	..	4 12 0
60,000	,,	,,	5	Do. 5 p.c. Pref.	121—123	..	4 1 4
117,058	,,	Jan. 13	5	Do. 5 p.c. Deb. Stk.	122—124	..	4 0 8
502,310	Stk.	May 12	5	Southampton Ord.	110—112	..	4 9 3
120,000	Stk.	Feb. 10	6⅞	Tottenham } A 5 p.c.	133—135	..	5 1 9
453,940	,,	,,	5⅝	and } B 3½ p.c.	113—115	..	4 13 6
149,470	,,	Dec. 29	4	Edmonton } 4 p.c. Deb.	99—101	..	3 19 3
182,380	10	June 10	8	Tuscan, Ltd.	9—9⅛*	..	8 8 6
149,900	10	Jan. 3	5	Do. 5 p.c. Deb. Red.	99—101	..	4 19 0
236,476	Stk.	Feb. 25	5	Tynemouth, 5 p c max.	113—115	..	4 6 11
255,636	Stk.	Feb. 25	6⅝	Wands- } B 3½ p.c.	139—141	..	4 14 0
79,416	,,	Dec. 29	3	worth } 3p.c. Deb. Stk.	74—76	..	3 18 11

Prices marked * are "Ex div."

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O'NEILL'S OXIDE
For GAS PURIFICATION.
LARGEST SALE OF ANY OXIDE.

SPENT OXIDE PURCHASED IN ANY DISTRICT.

GAS PURIFICATION & CHEMICAL CO., LD.,
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OLD BROAD STREET, LONDON, E.C.

WINKELMANN'S
"VOLCANIC" FIRE CEMENT.
Resists 4500° Fahr. Best for GAS-WORKS.
ANDREW STEPHENSON, 182, Palmerston House, Old Broad Street, London, E.C. "Volcanism, London."

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Best Percentages. For lowest Quotations to any Port, Station, or direct into Works, please apply to—
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SPECIALLY prepared for Sulphate of AMMONIA Makers by
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Address Correspondence and Inquiries to OLDBURY, WORCS.
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HYDRATED OXIDE OF IRON.
PREPARED from Pure Iron.
Twice as Rich as Bog Ore.
Gives no back Pressure.
The Cheapest in the Market.
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BROTHERTON AND CO., LTD., Ammonia Distillers.
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D. ANDERSON AND COMPANY,
GAS LIGHTING ENGINEERS AND CONTRACTORS,
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AMMONIACAL Liquor wanted.
CHANCE AND HUNT, LTD., Chemical Manufacturers, OLDBURY, WORCS.
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Works: BIRMINGHAM, GLASGOW, LEEDS, LIVERPOOL, SUNDERLAND, AND WAKEFIELD.

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Apply, THOMAS HORROCKS,
Albert Chemical Works, BRADFORD,
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Pitch, Creosote, Brick and Fuel Oils, Benzol, Solvent Naphtha, Carbolic, Sulphate of Ammonia.

J. E. C. LORD, Ship Canal Tar Works, Weaste, Manchester. Pitch, Creosote, Benzols, Toluol, Naphtha, Pyridine, all kinds of Cresylic Acid, Carbolic Acid, Sulphate of Ammonia, &c.

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JOHN RILEY & SONS, Chemical Manu-facturers, Hapton, near Accrington, are MAKERS of Special SULPHURIC ACID, for Sulphate of Ammonia Making. Highest percentage of Sulphate of Ammonia obtained from the use of this Vitriol, which has now been used for upwards of 50 Years. References given to Gas Companies.

F. BOYALL, Contractor for Painting GASHOLDERS, OIL-TANKS, ROOFS, and all kinds of LOFT and other PAINT WORK.
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Consumers in any form are invited to correspond with CHANCE AND HUNT, LTD., Chemical Manufacturers, OLDBURY, WORCS.

SULPHURIC ACID for Sale, specially suitable for making Sulphate of Ammonia.
BROTHERTON AND CO., LTD., Chemical Manufacturers, Works: BIRMINGHAM, LEEDS, SUNDERLAND, AND WAKEFIELD.

"GAZINE" (Registered in England and Abroad). A radical Solvent and Preventative of Naphthalene Deposits, and for the Automatic Cleaning of Mains and Services.
It is also used for the enrichment of Gas.
Manufactured and supplied by C. BOURNE, West Moor Chemical Works, KILLINGWORTH, or through his Agent, F. J. NICOL, Pilgrim House, NEWCASTLE-ON-TYNE.
Telegrams: "DORIC," Newcastle-on-Tyne. National Telephone No. 2497.

CAST-IRON Pipes. Spigot and Socket or Flanged. Special Quality—9 feet or 12 feet Lengths. When buying, Write us.
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The RELIANCE LUBRICATING OIL COMPANY supply the best value in NON-CORROSIVE LUBRICANTS—viz., Motor Waggon Oil, 1s.; Motor Car Oil, 2s.; Engine, Cylinder, and Machinery Oils, 1s.; Axle Oil, 10½d.; Exhauster Oil, 10d.; Special Cylinder Oil, 1s. 4d.; 650 T Cylinder, 2s.; Special Engine Oil, 1s. 4d.; Gas Engine and Oil Engine Oil, 1s. 6d.; Refrigerator, 1s. 9d.; Renown Engine Oil, 11½d.; and Astral Disinfectant, 2s. 6d. per gallon. Barrels free, carriage paid. Solidified Oil, 25s. cwt.
THE RELIANCE LUBRICATING OIL COMPANY, 19 & 20, Water Lane, Tower Street, LONDON, E.C.

GAS PLANT for Sale—We can always offer NEW and SECOND-HAND GAS APPARATUS, including Retorts and Fittings, Condensers, Exhausters, Scrubbers, Washers, Purifiers, Gasholders, Tanks, Valves, Connections, &c. Also a few COMPLETE WORKS. Compare Prices and Particulars before ordering elsewhere.
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PAINT FOR GAS-WORKS.
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SPECIALLY prepared for the Manu-facture of SULPHATE OF AMMONIA.
SPENCER CHAPMAN & MESSEL, LTD.
with which is amalgamated WM. PEARCE & SONS, LTD.
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GAS OILS.
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Represent the Strongest Independent Refineries in America; also Petroleum Spirit for Gas Enrichment. 18, EXCHANGE STREET, MANCHESTER, and 11, OLD HALL STREET, LIVERPOOL.

APPOINTMENTS.—Ambitious Men of Parts invited to write—
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"Have got the job. Quite a good start. To you the credit is due, and I think your fee the best investment I ever made."
BUSINESS IS REVIVING. WRITE NOW.

CITY and Guilds Examinations in Gas Engineering and Gas Supply. Students who have done badly at the recent Examinations should join Mr. Cranfield's Correspondence Classes for next Session. Assistance ample, individual, and private.
Write at once, 11, Avondale Place, HALIFAX.

WANTED, a Works Manager for Dol-gelley, North Wales. Make, 6,000,000 Cubic Feet. Coal Trade. Wages, 35s., with House, &c.
Apply, with copies of recent Testimonials, stating Age, number in family, &c., to G. E. WOODFORD, RUABON.

WANTED, for a 100 Million Works, an ASSISTANT GAS MANAGER. Must be Technically Qualified.
Applicants are requested to give full Particulars of their Training and Qualifications, and to send *Copies* of not more than Three recent Testimonials, to No. 5256, care of Mr. King, 11, Bolt Court, FLEET STREET, E.C.

REQUIRED, a Working Retort-House and Yard FOREMAN, experienced in Working Carburetted Water-Gas and Sulphate of Ammonia Plants. Works near London, 80 Million. House on Works.
Apply, by letter, enclosing *copies* of Testimonials, stating Age, Salary expected, and when Disengaged, to No. 5255, care of Mr. King, 11, Bolt Court, FLEET STREET, E.C.

THE UNIVERSITY OF SHEFFIELD.
APPOINTMENT OF LECTURER IN APPLIED CHEMISTRY.
THE Council are about to appoint a LECTURER IN APPLIED CHEMISTRY.
Salary, £150 per Annum.
Applications must be sent in by July 9.
Further Particulars may be obtained from
W. M. GIBBONS,
Registrar.

THE Omagh Urban District Council require the Services of a Competent GAS MANAGER, who will be required to keep a plain set of Books.
Salary, £120 per Annum, with free House, Coal, and Gas.
Applications, with *copies* of Testimonials, must be lodged on or before Tuesday, the 28th inst.
WM. J. CORKER,
Clerk to the Council.
Urban Council Chambers, Omagh,
June 9, 1910.

FOR SALE—Good Second-Hand Dry Tin-Cased GAS-METERS, made by the Gas Meter Company, Limited. One 300-Light; Two 200-Light; Four 100-Light; One 50-Light. Just been displaced by Electricity.
Apply, by letter, to No. 5251, care of Mr. King, 11, Bolt Court, FLEET STREET, E.C.

ROBERT DEMPSTER & SONS, Ltd.,
Contractors for Complete CARBONIZING PLANTS and every description of GAS APPARATUS and ELEVATING and CONVEYING PLANT, Ross Mount Iron-Works, Elland.

GASHOLDERS—Splendid 45 feet diameter and New STEEL TANK, fixed Complete to Plan and Specification; also 14 feet and 16 feet Diameter GASHOLDERS, with STEEL TANKS. Can be seen temporarily erected. Re-erected Cheap for immediate Sale.
Firth Blakeleys, Thornhill, Dewsbury.

THE Directors of the Keswick Gas Company invite TENDERS for the Supply of 2000 Tons of Best Screened GAS COALS or NUTS, to be delivered at Keswick Railway Station between the 1st day of July, 1910, and the 1st day of July, 1911, in such Quantities and at such times as may be required.
Tenders, stating Price per Ton, endorsed "Tender for Coal," to be sent to the undersigned not later than the 23rd inst.
The Directors do not bind themselves to accept the lowest or any Tender.
No Form of Tender supplied.

J. H. Brodie,
Secretary.

Main Street, Keswick,
June 10, 1910.

THE Directors of the Keswick Gas Company invite TENDERS for their Surplus TAR and AMMONIACAL LIQUOR for Twelve Months from the 30th inst., at per Ton delivered into Contractors' Tanks at Keswick Railway Station.
Tenders, endorsed "Tender for Tar," or "Tender for Liquor," will be received by the undersigned up to Four p.m. of Thursday, the 23rd inst.; but the Directors do not bind themselves to accept the highest or any Tender.
Forms of Tender are not supplied.

J. H. Brodie,
Secretary.

Main Street, Keswick,
June 10, 1910.

KEIGHLEY CORPORATION GAS-WORKS.

THE Gas Committee invite Tenders for the Supply of the following MATERIALS required during the Twelve Months commencing on the 1st of July next:—
CAST-IRON PIPES and OTHER CASTINGS.
B. O. VITRIOL.
LIME.
Also for the Purchase of SPENT OXIDE during the same period.
Particulars and Form of Tender can be obtained on Application.
Tenders to be sent in on or before the 27th inst.

W. Baillie,
Engineer.

Gas Offices, Cook Lane,
Keighley, June 11, 1910.

RHONDDA URBAN DISTRICT COUNCIL.
(Gas and Water Department.)

NEW STEEL TAR AND LIQUOR TANK, SCRUBBER, AND TWO PURIFIERS—CONTRACT No. 49.

THE Council are prepared to receive TENDERS for a STEEL TAR AND LIQUOR TANK, SCRUBBER, and Two PURIFIERS, for their Porth Gas-Works.
Plans and Specification may be seen, and Forms of Tender obtained, upon Application to Mr. Octavius Thomas, the Engineer and Manager, Gas and Water Offices, Pentre, Rhondda, upon depositing the sum of One Guinea, which will, after the Council have entered into a Contract upon the Tenders received, be returned to the Tenderer, provided that he shall have sent in a *bonâ-fide* Tender, and shall not have withdrawn same.
The Contractor will be required to pay the Standard Rate of Wages recognized in the District.
Tenders to be addressed to the Chairman of the Gas and Water Committee, endorsed "Contract No. 49," and delivered at my Office not later than 10 a.m. on Friday, the 1st day of July next.
The Council do not bind themselves to accept the lowest or any Tender.

Walter P. Nicholas,
Clerk to the Council.

Public Offices, Pentre, Rhondda,
June 17, 1910.

RHONDDA URBAN DISTRICT COUNCIL.
(Gas and Water Department.)

THE Council are prepared to receive TENDERS for the following:
1.—The Supply from the 1st of July, 1910, to the 30th of June, 1911, of 18,500 Tons of Through and Through GAS COAL and 1500 Tons of CANNEL, delivered at the Porth and Ystrad Gas-Works.
2.—For the Supply and Delivery of CAST-IRON PIPES required from the 1st of July, 1910, to the 30th of June, 1911.
Specifications and Forms of Tender can be obtained on Application to the Engineer and Manager, Mr. Octavius Thomas, Gas and Water Offices, Pentre, Rhondda.
The Contractors will be required to pay the Standard Rate of Wages recognized in the District.
Tenders to be addressed to the Chairman of the Gas and Water Committee, endorsed "Tender for Gas Coal," "Cannel," or "Cast-Iron Pipes," as the case may be, and delivered at my Office, not later than Thursday, the 30th day of June, 1910.
The Council reserve to themselves the right to divide the Quantity into two or more Contracts, and do not bind themselves to accept the lowest or any Tender.

Walter P. Nicholas,
Clerk to the Council.

Public Offices, Pentre,
Rhondda, June 16, 1910.

NORTHWICH GAS COMPANY.

THE Directors of the Northwich Gas Company invite TENDERS for the Supply of about 7000 Tons of GAS COAL during the Year ending June 30, 1911.
Full Particulars and printed Form of Tender may be had on Application to the undersigned.
Tenders, endorsed "Coal," are to be sent in addressed to the Chairman, by Thursday, June 23, 1910.

Saml. S. Mellor,
Manager and Secretary.

Gas-Works, Northwich.

BOROUGH OF EAST RETFORD.

TENDERS FOR GAS COAL.

THE Gas Committee of the above Corporation are prepared to receive TENDERS for the Supply and Delivery at the Sidings of the Great Northern or Great Central Railway Companies, Retford, of 8000 Tons of Best Screened GAS COAL or NUTS during the Year ending June 30, 1911.
The Coal must be Freshly Worked and free from Bats, Bind, or other objectionable matter.
Sealed Tenders, Specifying the quality of the Coal and the name of the Pit from which it is raised, to be sent in on or before June 30, 1910, addressed to the Chairman of the Gas Committee, endorsed "Tender for Gas Coal."
Forms of Tender and any further Particulars may be obtained from the undersigned.

J. B. Fenwick,
Engineer and Manager.

Gas and Water Office,
Retford, June 9, 1910.

TEIGNMOUTH URBAN DISTRICT COUNCIL.

THE Gas Department of the above Council invite TENDERS for the Supply of 4000 Tons of Best Durham or other good GAS COAL, Screened or Unscreened. The same to be supplied to the requirements of the Council between the 31st day of July, 1910, and the 30th day of June, 1911.
The Coal must be fresh Wrought and free from all impurities.
No Special Tender Form will be issued.
Tenders must be accompanied by a full Description, and Practical Working Analysis of the Coals quoted and may be either f.o.b. at port of shipment, Teignmouth Harbour, f.o.r. Teignmouth Railway Station, or delivered into the Gas-Works Store.
Sealed Tenders endorsed "Gas Coals," to be addressed to A. Percival Dell, Esq., Clerk to the Council, Town Hall, Teignmouth, and delivered not later than Monday, the 4th day of July, 1910.
The Committee do not bind themselves to accept the lowest or any Tender.

By order,
J. Alex. Gray,
Gas Manager

Gas-Works, Teignmouth,
June 11, 1910.

FILEY URBAN DISTRICT COUNCIL.

TENDERS FOR COAL.

THE Council invite Tenders for the Supply of 1800 to 2000 Tons of GAS COAL, in the Twelve Months ending the 30th of June, 1911.
Delivery to be made at the North-Eastern Railway Company's Depôt, Filey.
The Coal must be of good quality, suitable for Gas Making, and free from Bats, Pyrites, and other Refuse.
The Tender may be for Screened, Unscreened Coal, or Nuts.
Payments will be made Monthly.
The following are the approximate Monthly Quantities required:—

1910.		1911.	
July . .	160 Tons	Jan. . .	170 Tons.
Aug. . .	250 ,,	Feb. . .	140 ,,
Sept. . .	200 ,,	March .	140 ,,
Oct. . .	160 ,,	April . .	110 ,,
Nov. . .	160 ,,	May . .	110 ,,
Dec. . .	190 ,,	June . .	100 ,,
	1120		770

Tenders to be addressed to the Chairman, Urban Council, Filey, and to be sent in on or before the 27th of June, 1910.

Henry Tobey,
Engineer.

Malton.

MANSFIELD CORPORATION.
(Gas Department.)

TENDERS FOR GAS COAL, CANNEL, AND LIME,
AND
TENDERS FOR SURPLUS TAR.

Coal.

THE Gas Committee are prepared to receive TENDERS for 1000 Tons of CANNEL and 12,000 Tons of Best Screened GAS COAL, Delivered at Mansfield Station for One Year from the 1st of July, 1910, to the 30th of June, 1911.

Lime.

For the Supply of about 150 Tons of Best Hand Picked LIME. Delivered as above.

Tar.

TENDERS for Surplus TAR made from the 1st of July, 1910, to the 30th of June, 1911.
Tenders, endorsed "Coals," "Lime," or "Tar," as the case may be, to be sent to J. Harrop White, Esq., Town Clerk, Mansfield, on or before June 29, 1910.
Particulars and all other Information from the undersigned.
Note: *No Special Forms of Tender provided.*
The Committee do not bind themselves to accept the lowest or any Tender.

Arthur Graham,
Engineer and Manager.

Gas-Works, Mansfield,
June 8, 1910.

BOROUGH OF CONGLETON.
(Gas Department.)

THE Gas Committee invite Tenders for the Purchase of Surplus TAR and AMMONIACAL LIQUOR for the Twelve Months ending June 30, 1911.
Forms of Tender and Conditions may be obtained from the undersigned.
Tenders, endorsed "Tar and Liquor," to be delivered at the Office of E. A. Plant, Esq., Town Clerk, Congleton, on or before Saturday, July 2, 1910.
The Committee do not bind themselves to accept the highest or any Tender.

Joseph T. Broughton,
Engineer and Manager.

Gas-Works, Congleton,
June 13, 1910.

BRIERLEY HILL DISTRICT GASLIGHT COMPANY.

TENDERS FOR SURPLUS TAR.

THE Directors invite offers for the Surplus TAR made at their Brierley Hill and Kingswinford Works, to be taken between July 1 next and June 30, 1911, delivered into Buyer's Boats.
Quotations to be based on the rate of 200 Gallons to the Ton.
The Directors do not bind themselves to accept the highest or any Tender.
Sealed Tenders, to be addressed to the Chairman and endorsed "Tender for Surplus Tar," not later than the 30th inst.

Henry M. Jackson,
Secretary.

Board Room, Gas-Works,
Brierley Hill, June 14, 1910.

EGREMONT (CUMBERLAND) URBAN DISTRICT COUNCIL.

THE Council are prepared to receive TENDERS for the Extension of the Gas-Works.
Contract No. 2.—GASHOLDER TANK and GASHOLDER.
Contract No. 3.—FOUR PURIFIERS.
Contract No. 4.—STATION METER.
Full Particulars and Copy of the Bill of Quantities may be obtained from the Engineers' Messrs. Thomas Newbigging and Son, 5, Norfolk Street, Manchester, on deposit of One Guinea, returnable on receipt of a *bonâ-fide* Tender.
The Drawings and Specifications may be seen at the Engineers' Office or at the Gas-Works, Egremont.
The lowest or any Tender not necessarily accepted.

By order,
John Bowly,
Clerk to the Council.

Town Hall, Egremont,
June 14, 1910.

WOMBWELL URBAN DISTRICT COUNCIL.
(Gas and Water Departments.)

COAL AND COKE HANDLING PLANT.

THE Gas and Water Committee of the above Council invite TENDERS for the Supply, Delivery, and Erection of a COAL and COKE HANDLING PLANT, at the Gas-Works, Wombwell.
Full Particulars may be had on Application to the undersigned.
The Council do not bind themselves to accept the lowest or any Tender.
Tenders, endorsed "Coal and Coke Handling Plant," addressed to the Chairman of the Gas and Water Committee, to be delivered here on or before Wednesday, June 29, 1910.

Signed, P. D. Walmsley, B.Sc.,
Engineer and Manager.

Gas-Works Wombwell,
June 17, 1910.

COUNTY BOROUGH OF SALFORD.

THE Gas Committee invite Tenders for the following MATERIALS, in such Quantities as may be required during the Thirteen Months ending the 30th of September, 1911: GAS-METERS, CAST-IRON MAIN PIPES and CONNECTIONS, IRON CASTINGS, GAS and STEAM TUBING and SUNDRY FITTINGS, IRON and STEEL, GUN-METAL METER and LAMP TAPS and METER KEYS, BRASS FITTINGS for METERS, BRASS PENDANTS and BRACKETS, LEAD PIPE, ROPES, TARRED and SPUN YARN and TWINE, OILS and TALLOW, PAINTS, BRUSHES, INDIA-RUBBER TUBING, SHEETING, &c., TIMBER.
Forms of Tender and all Information may be obtained, and Samples seen, on Application to Mr. Wm. W. Woodward, Gas Engineer, Bloom Street, Salford.
Sealed Tenders, endorsed "Tender for Stores," addressed to the Chairman of the Gas Committee, Town Hall, Salford, to be delivered to me not later than Three p.m. on Thursday, the 30th of June, 1910.

L. C. Evans,
Town Clerk.

Salford.

SUTTON-IN-ASHFIELD URBAN DISTRICT COUNCIL.

GAS-WORKS EXTENSION.

PERSONS desirous of Tendering for the Supply (*a*) of CAST-IRON PIPES and SPECIALS and (*b*) WROUGHT-IRON TUBES and FITTINGS are requested to send their names and addresses to Messrs. Corbet Woodall and Son, Palace Chambers, Bridge Street, Westminster, S.W., not later than Saturday, the 25th day of June, 1910, together with a deposit of £3 3s. (by cheque) for copy of Specification, Schedule of Quantities, and Form of Tender.
The Deposit will be returned on receipt of a *bonâ-fide* Tender.
The lowest or any Tender will not necessarily be accepted.
Contractors should State in their Application whether they require Specifications "A" or "B."

John D. Fidler,
Clerk to the Council.

Council Offices, Sutton-in-Ashfield.

CITY OF HEREFORD.
(GAS DEPARTMENT.)

TENDERS are invited for the Surplus TAR produced at these Works, during the Twelve Months ending June 30, 1911.

Sea ed Tenders, addressed to the Chairman of the Gas Committee, should be delivered at the Town Hall on or before the 25th inst., endorsed "Tender for Tar,"

W. W. TOWNSEND,
Engineer and Manager.

Gas-Works, Hereford,
June 16, 1910.

CITY AND COUNTY BOROUGH OF BELFAST.

THE Gas Committee of the Corporation invite TENDERS for a Supply of 105,000 Tons of best Screened GAS COAL, to be delivered free, and trimmed, in barges at Belfast Harbour, between the 1st of October, 1910, and the 30th of September, 1911.

No Tender for less than 10,000 Tons will considered.

Particulars as to the Quantity required each Month, &c., may be obtained at the Gas-Works.

Tenders on Office Forms, endorsed "Tender for Coal," should be lodged in the Office of the undersigned not later than Ten a.m. on the 1st of July, 1910.

The lowest or any Tender not necessarily accepted.

R. MEYER,
Town Clerk.

BOROUGH OF ILKESTON.
(GAS DEPARTMENT.)

THE Gas Committee invite Tenders for 11,000 Tons of Screened GAS NUTS or PEAS to be delivered at their Siding on the Midland Railway, as required for the Year ending July 31, 1911.

Sealed Tenders, endorsed "Tenders," on Forms to be had on Application to the undersigned, to be delivered to Wright Lissett, Esq., Town Clerk, Ilkeston, before July 6.

The Committee reserve the right to divide the Quantities offered and do not pledge themselves to accept the lowest or any Tender.

F. C. HUMPHRYS,
Engineer and Manager.

Gas-Works, Ilkeston,
June 17, 1910.

FARNWORTH AND KEARSLEY GAS COMPANY.

THE Directors are prepared to receive TENDERS for their Surplus Make of TAR and AMMONIACAL LIQUOR for a Term of One Year commencing the 1st of July, 1910.

Sealed Tenders to be addressed to James Fletcher, Esq., J.P., Chairman, Gas Offices, Cross Street, Farnworth, near Bolton, and delivered not later than Wednesday, the 29th of June next.

Forms of Tender and any further It formation required may be obtained from Mr. H. Pickford, Manager.

W. BROMLEY,
Secretary.

Gas Offices, Farnworth,
June 10, 1910.

SALES BY AUCTION OF GAS AND WATER STOCKS AND SHARES.

MESSRS. A. & W. RICHARDS beg to notify that their SALES BY AUCTION of NEW CAPITAL ISSUED UNDER PARLIAMENTARY POWERS, and of STOCKS and SHARES belonging to EXECUTORS and other PRIVATE OWNERS in LONDON, SUBURBAN, and PROVINCIAL GAS and WATER COMPANIES, take place PERIODICALLY at the Mart, TOKENHOUSE YARD, E.C.

Terms for Issuing New Capital, and also for including other Gas and Water Stocks and Shares in these Periodical Sales, will be forwarded on Application to MESSRS. A. & W. RICHARDS, at 18, FINSBURY CIRCUS, E.C.

By order of the Directors of the
CHIGWELL, LOUGHTON, AND WOODFORD GAS COMPANY.

NEW ISSUE OF
£2000 CONSOLIDATED ORDINARY STOCK AND £1000 FOUR PER CENT. PERPETUAL DEBENTURE STOCK.

MESSRS. A. & W. RICHARDS will SELL THE ABOVE BY AUCTION, at the Mart, E.C., on Tuesday, June 28, at Two o'clock, in Lots.

Particulars of the AUCTIONEERS, 18, FINSBURY CIRCUS, E.C.

BRENTFORD GAS COMPANY,
PINNER GAS COMPANY,
ILFORD GAS COMPANY.

MESSRS. A. & W. RICHARDS will SELL BY AUCTION, at the Mart, E.C., on Tuesday, June 28, at Two o'clock, in Lots, Stocks and Shares in the above Companies.

Particulars of the AUCTIONEERS, 18, FINSBURY CIRCUS, E.C.

By order of the Directors of the
BARNET DISTRICT GAS AND WATER COMPANY.

NEW ISSUE OF £10,000 "D" CAPITAL WATER STOCK.

MESSRS. A. & W. RICHARDS will SELL THE ABOVE BY AUCTION, at the Mart, E.C., on Tuesday, July 12, at Two o'clock, in Lots.

Particulars of the AUCTIONEERS, 18, FINSBURY CIRCUS, E.C.

HORNSEY GAS COMPANY.

NOTICE is Hereby Given, that the TRANSFER BOOKS of this Company, relating to DEBENTURE STOCK ONLY, WILL BE CLOSED on the 17th inst., and RE-OPENED on July 1, 1910.

By order of the Board,
WILLIAM E. ROBERTS,
Secretary.

63, Chancery Lane, W.C.,
June 16, 1910.

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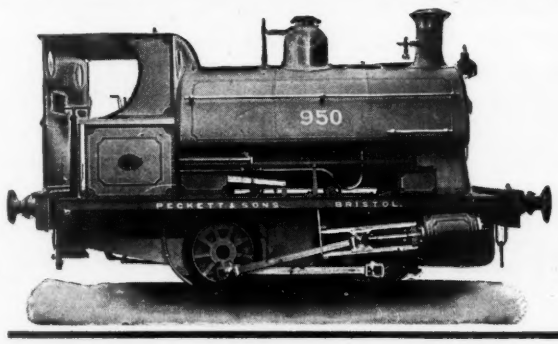

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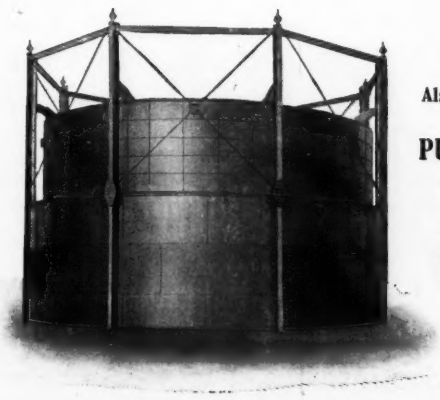

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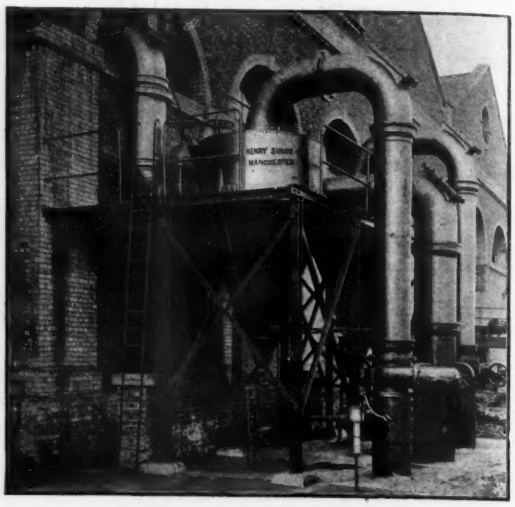

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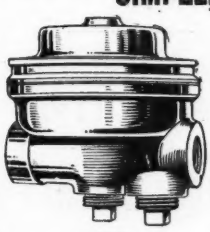

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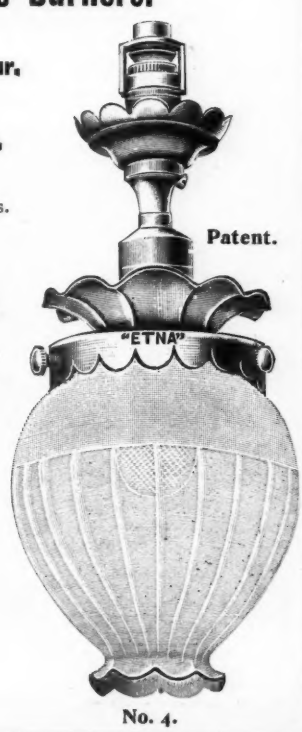

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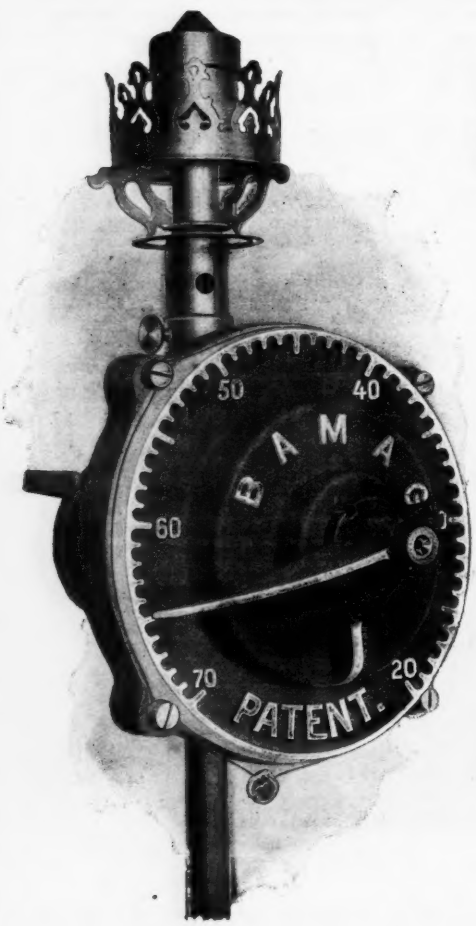

OVER

59,500 IN OPERATION.

(INCREASE SINCE LAST YEAR 19,500).

SUITABLE FOR ALL PRESSURES AND ALL CONDITIONS.

SUITABLE FOR ALL BURNERS, UPRIGHT OR INVERTED.

Full Particulars on Application to

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EXHAUSTERS.

Converted to easily pass 40 to 80% or even 100% more through

Existing Gas Connections

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For new machinery we can do still better. Even the Converted Exhauster is suitable for any pressure up to 200 inches on the Water Gauge.

In case of emergency our Exhausters would pass an additional 50 per cent.

ERNEST B. WALLER & CO., Brimscombe Wharf, STROUD.

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CONTRACTORS FOR ALL QUALITIES OF

GAS COAL AND CANNEL

Contracts made for delivery by rail to any Station or f.o.b. and c.i.f. to any port.

Gas Engineers' Agents for **METERS, FIRE-CLAY GOODS,** and all other Gas Apparatus.

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WROUGHT-IRON OR STEEL MAINS UP TO 6 FEET DIAMETER FOR GAS, WATER, OIL, OR OTHER PURPOSES.

SCREWING TACKLE, BOILER MOUNTINGS, VALVES, COCKS, ETC.

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OVER 600
ROTARY
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T. G. MARSH,
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WATER SUPPLIES.
ARTESIAN BORED TUBE WELLS,
Norton's Patent "Abyssinian" Tube Wells.
Deep Well Pumps and Patent Air Lift Pumps.
LE GRAND & SUTCLIFF,
Artesian Well and Waterworks Engineers,
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ARROL-FOULIS
Stoking Machinery
HYDRAULIC COKE PUSHERS
(HUNTER and BARNETT'S PATENT).
WILL DISCHARGE A RETORT IN ONE OPERATION
LARGE NUMBERS IN USE.
Full Particulars may be obtained from the Sole Makers,
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[See Illustrated Advertisement, June 14, p. 728.]

BEST & LLOYD, LTD.,
BIRMINGHAM.
BEST'S
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SURPRISE.

SPECIAL NOTICE.
See that every Pendant bears our Trade Mark (as above) stamped upon the balance weights!!!
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GAS PENDANT.

CASES FOR BINDING
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PROJECTS AND INSTALLATIONS OF WATER-GAS-PLANTS
On the Strache System.
STEAM-CONTROLLER for Water-Gas-Plants
RAISES the Calorific Value up to 3000 Calories.
REDUCES the CO_2 Contents to 2 per cent.
INCREASES the Capacity of the Unit-Time.
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AUTOLYSATOR
Apparatus for Use in Heating-Plants of All Kinds, registering continuously and visibly the CO_2.
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Apparatus serving to Find out the Leakage in Gas-Mains.
Representative for England:—G. PETTIGREW, THORNABY-ON-TEES, ENGLAND.

SILICA MACHINE MADE RETORTS.
TRADE "C.O." MARK. REGISTERED.
THE NEW RETORT
Will withstand high temperatures and is **Guaranteed not to Contract or Soften** under Heat.
GREATER CONDUCTIVITY THAN ANY FIRE-CLAY RETORT.
For Particulars and prices apply—
JOSEPH MORTON, LTD.,
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CAST-IRON PIPES FOR GAS, WATER, & STEAM,
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(*One of the OLDEST MAKERS in the TRADE*),

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CONSTRUCTIONAL IRON AND STEELWORK.

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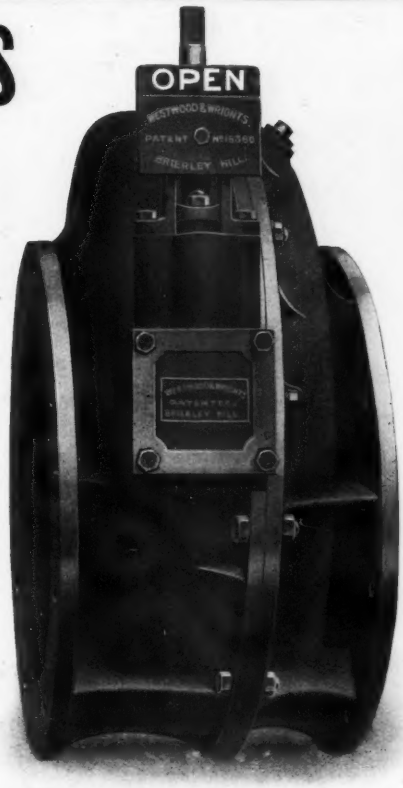

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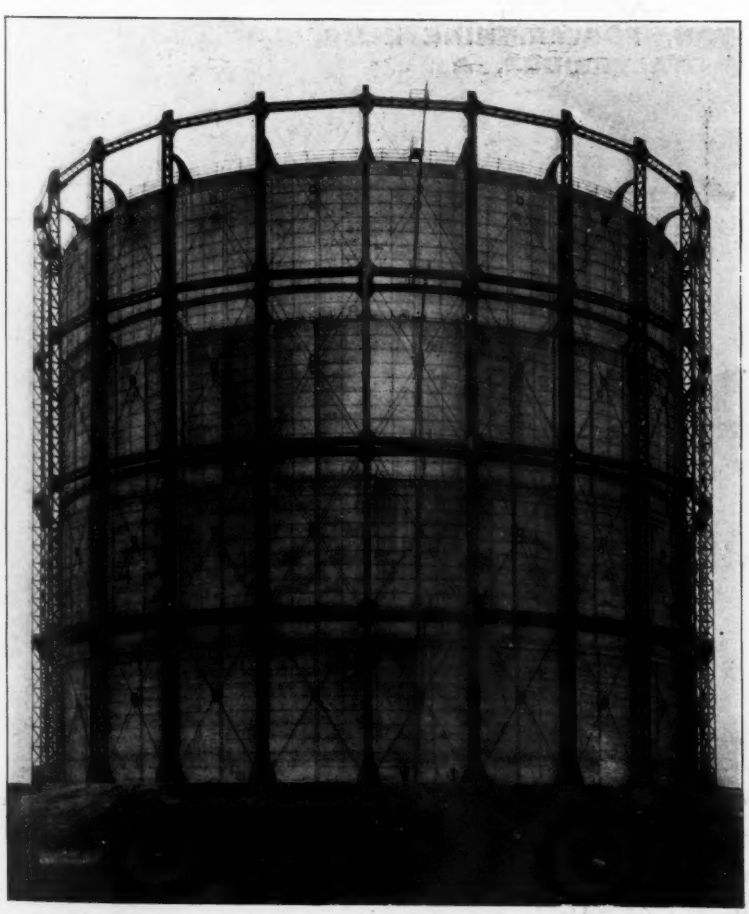
PATENT DETACHABLE FACES FOR MOUTHPIECES.



Four-Lift Gasholder, 199 ft. 6 in. dia. × 42 ft. 0 in. deep, erected at the East Ham Gas-Works.

PATENTEES
of
The MOST RELIABLE GAS VALVE
with
PATENT LUBRICATING FACES
and
PATENT INDICATORS.

AUTOMATIC FASTENINGS
for
RETORT MOUTHPIECES.

PRESSURE RELIEVERS
for
GASHOLDER CUPS.

FURNACE AND OTHER DOORS
also
RETORT MOUTHPIECES
with
ASBESTOS JOINTS.

CORT'S

COKE CUTTING MACHINES.

The Value of the Coke is enhanced owing to its being

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TO ANY DESIRED SIZE

UNIFORM

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FREE FROM DUST.

We believe they are indispensable for obtaining

Maximum Efficiency and Economy.

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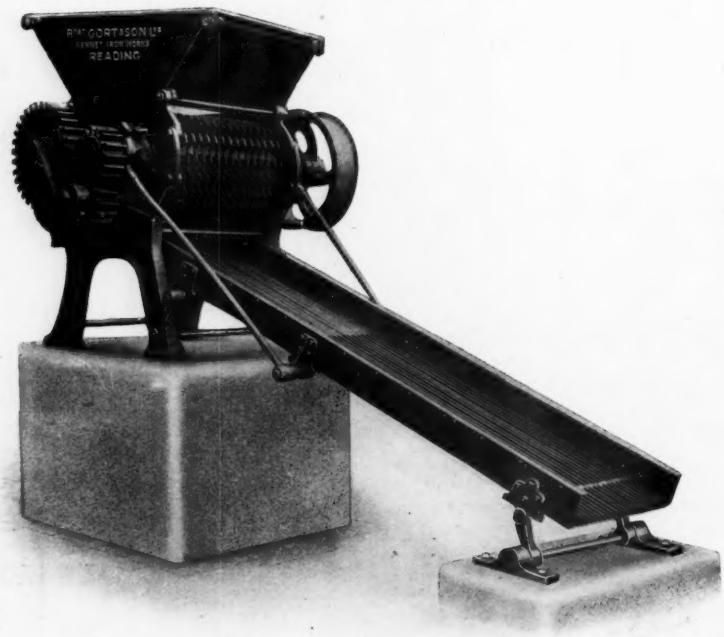

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MARSH AND THORP'S SPECIALITIES.

Carbonizing Foremen with anxiety to show good yield of Gas frequently increase the suction on the Retorts—Result: Air or Air and Furnace Gas is mixed with the Coal Gas. The Gas Manager with one of our Registers sees the game **AT ONCE**, and nips it in the bud.

Arranged as EXHAUST, or EXHAUST and PRESSURE, or as PRESSURE REGISTERS.

PRICES.

6 in. RANGE	- - -	£8 10 6
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Deficiency of Pressure and variation of Pressure are the most fruitful source of Consumers' complaints.

A Portable Register at once enables you to locate your difficulties.

PRICES.

For 4 in. or 6 in. Pressure, 24 hours diagram	£7 0 0
,, ,, ,, ,, 7 days ,,	7 10 0
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No Engineer can have thorough control of his Water-Gas Plant who has not a Cycle Recorder to show what his attendants are doing.

Marsh and Thorp's Cycle Recorder (Patented) shows duration of Runs, Blows, Time of Coking, Time of Clinkering, and Extent of Carburation.

It will increase the life of your Generators and Reduce the Cost of Purification.

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SPECIAL REGISTERS for use with Retort House Governors.

DIFFERENTIAL REGISTER Showing Loss of Pressure from Inlet or Outlet of Plant.

ENQUIRY INVITED:

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GAS & MECHANICAL SPECIALTY CO.
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Telephone No. 5029 CITY.
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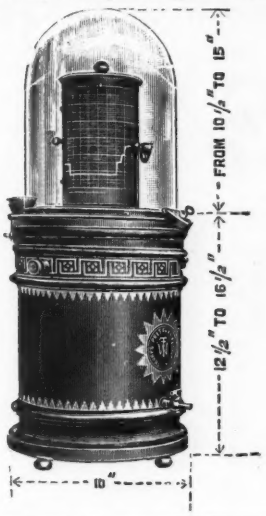
Exhaust Register.
"A little neglect may breed great mischief."



Portable Register.
"What is done by night appears by day."

Water-Gas Cycle Recorders.
"Let each part of your business have its time."

PREPAYMENT METER

SIMPLEX

The **SPECIAL FEATURES** of this Meter are that without Removing the Meter you can, by merely unlocking padlock of money box and lifting up the flap at the side, **CHANGE** the price.

NO seals to hack out.
NO screw head to find.
NO reaching over meter.
NO numbers to look for.
NO re-screwing.
NO re-sealing.
NO bent coins can be inserted in the mechanism.
NO second coin can be inserted until previous one released by turning the handle.

AUTOMATIC GAS LIGHTER AND EXTINGUISHER.

Some of its Special Advantages are:—

1. It is instantaneous in Lighting and Extinguishing without shock to Mantle, and can be set to its pre-determined times in a few seconds.
2. The mechanism will act correctly, even though the Lamp-post and Controller be out of the perpendicular.
3. **THE VALVE.**—As this never leaves its seat, and the gasways being away from the seating, no impurities can collect between the valve and the seating, and by simply removing a small cap, the gasways can be freed of Naphthalene or any other matter.
4. The leakage of gas into the clock mechanism and its resultant troubles are entirely done away with.
5. Vibration of any description will not cause the Mechanism to operate prematurely.
6. The "Simplex" Clock has a Lever Escapement.

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Telephone: 204X NOTTINGHAM.

LONDON DEPOT:
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Telegraphic Address: "GASOMETER LONDON."
Telephone: 2044 HOP.

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Telegrams: "VERTICAL, LEEDS."

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ENGINEERS AND CONTRACTORS.

BEING AN AMALGAMATION OF
GRAHAM, MORTON & CO.,
LEEDS,
AND
R. H. LONGBOTHAM & CO,
LTD, WAKEFIELD.

PARTNERS.

CLAYTON, SON & CO., LTD., LEEDS.
WILLIAM J. B. LEECH,
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MAKERS OF
ELEVATING & CONVEYING MACHINERY,
ROOFS, BUNKERS,
COLLIERY SCREENING PLANTS,
PICKING BELTS,
PIT HEAD GEARS, HEAPSTEADS,
HAULAGE GEARS.

BUILDERS OF
GAS RETORT INSTALLATIONS,
ON THE
HORIZONTAL, INCLINED,
OR
VERTICAL SYSTEMS.

Gentlemen,

We have pleasure in informing you that an amalgamation has been arranged between the firms of

GRAHAM, MORTON & CO., of LEEDS,

whose speciality work is the manufacture of Elevating and Conveying Machinery, Roofs, Bunkers, Steel Structural Work, etc.; also Builders of Gas Retort Installations on the Horizontal, Inclined and Vertical Systems, and

R. H. LONGBOTHAM & CO., Ltd., of WAKEFIELD,

makers of Colliery Screening Plants, Picking Belts, Heapsteads, Pit Head Gears, Haulage Gears, etc., and that in future the business will be continued under the style or firm of

LEECH, GOODALL & CO.,

at the above address.

Whilst thanking the many clients of the two firms for past favours we trust that they will place our name on their Books and that we shall receive a continuance of their esteemed orders, to which every attention will be given both as regards quality of material and good workmanship, together with satisfactory working and results.

Yours faithfully,

Leech, Goodall & Co

CORKSTONE COMPANY.

HEAT INSULATION SPECIALITIES.

"THERMALIT" Fireproof Material.

Moulded into circular segments and bricks.

Can be exposed directly to dry heat of 2000° F. Spec. Gravity = ·3. Heat Saving capacity = 97·4 per cent. Chiefly used for lining the setting of Water Tube Boilers, Coke Ovens, Retorts, &c., in order to economise heat and protect the brickwork against destruction caused by atmospheric cooling action; for lagging of superheated steam and plant using very high temperatures.

"EMULGIT" Corkstone.

Moulded into circular segments, slabs, and bricks.

Spec. Gravity = ·25. Waterproof. Largely used in building on account of lightness and high capacity to confine or exclude heat, for encasing ironwork as a protection against fire, lining iron roofs, building partition walls, and lagging Steam Plant and Cold Water Pipes.

"REFORM" Impregnated Corkstone.

Moulded into circular segments, slabs, and bricks.

Spec. Gravity = ·3. Frost and water proof. A specially prepared "Emulgit" for insulation and storage of Cold, also for lagging Refrigerator Plant.

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STOURBRIDGE, ENGLAND.

PROPRIETORS OF

Stourbridge Fire Clays

Manufacturers of

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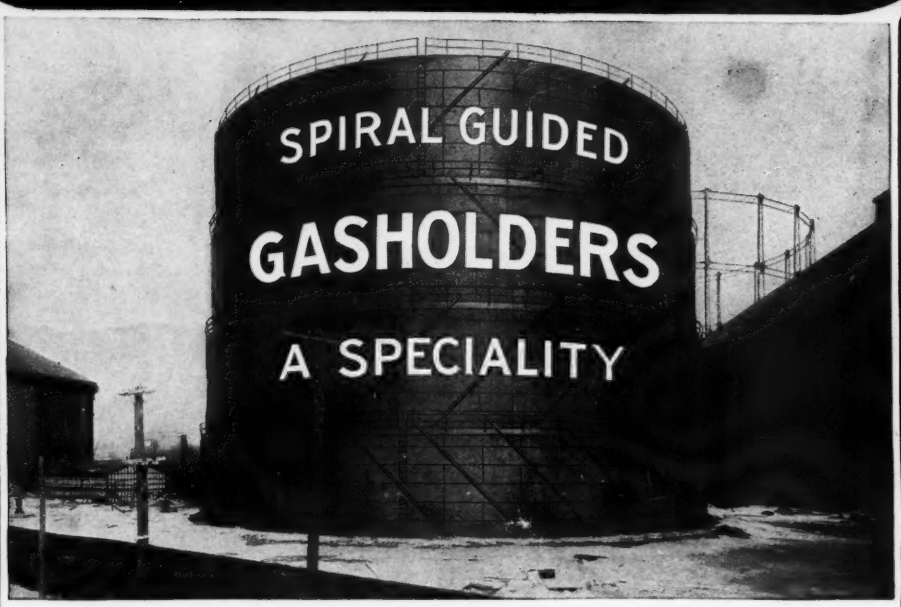
COKE-OVEN BRICKS A SPECIALITY.

GAS COAL AND CANNEL CONTRACTORS.

CLAYTON SON & CO., LTD.

HUNSLET, LEEDS.

Makers of the first
SPIRAL GUIDED HOLDER (1889)



Four-Lift Spiral Guided Gasholder, erected at Montreal (Canada), capacity **1,000,000** cubic feet, fitted with "Clayton and Pickering's" Patent Guides.—The Strongest ever invented. The above Holder was completed in October, 1908, and has worked with perfect satisfaction, amid the trying conditions of a Canadian Winter.

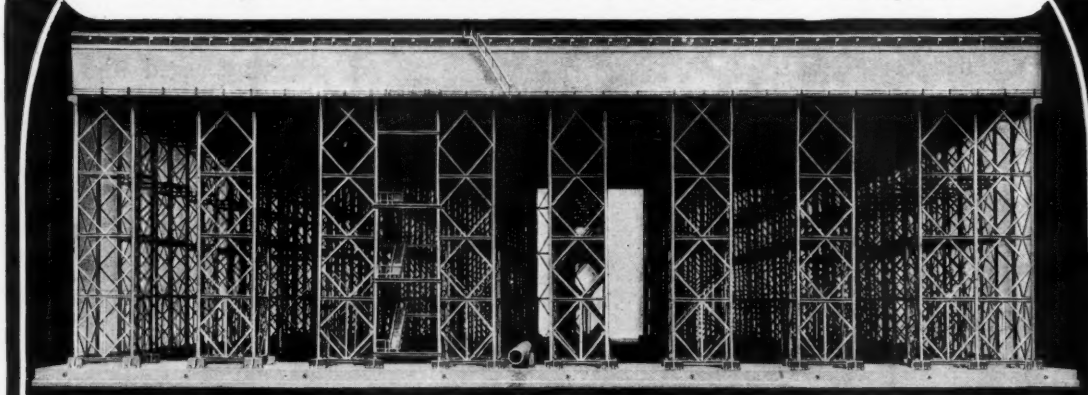
STEEL WATER MAINS A SPECIALITY.

21 Miles—33 inches diameter—just completed for the Leeds Corporation.

PHOTOGRAPH OF THE MODEL OF THE ELEVATED RESERVOIR,

To be Made and Erected by **CLAYTON, SON, & CO., LTD.**, for the CORPORATION OF CALCUTTA, at their TALLAH WATER-WORKS.

To the Designs of W. B. MacCABE, Esq., M.Inst.C.E., F.I.C., Chief Engineer to the Corporation.

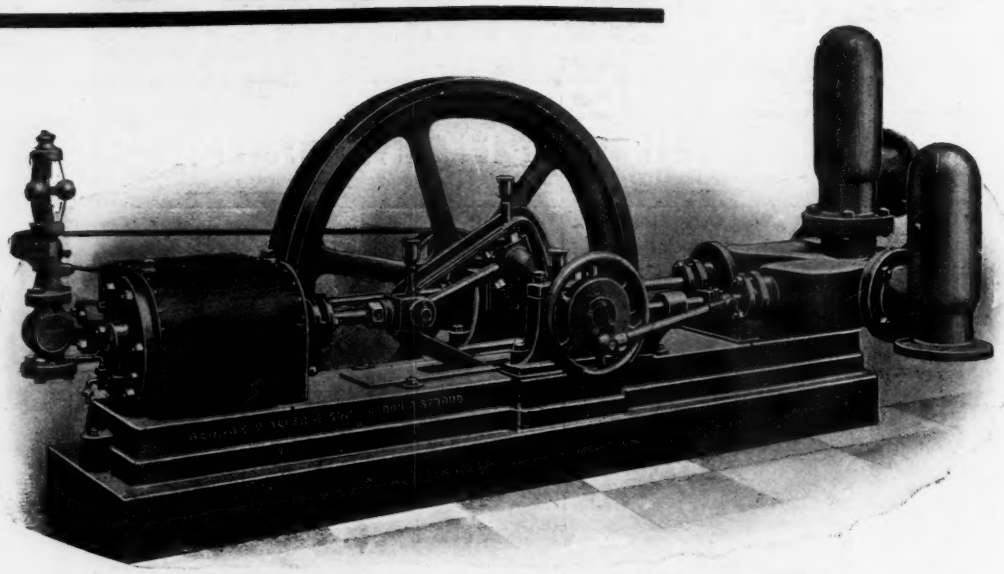


The Reservoir will consist of a Steel Tank, 16 feet deep, 321 feet square, supported on Steel Stanchions, the height from the top of tank to ground level being 110 feet. The tank will have a capacity of 9,000,000 gallons, weighing about 40,000 tons. The tank will be divided into four compartments which can be used independently of each other. The steel comprised in this huge structure will amount approximately to 7,000 tons.

Telegrams, "GAS, LEEDS." London Office, 60, QUEEN VICTORIA ST. E.C.

PUMPS

For GAS-WORKS PURPOSES,
Specially Designed for
TAR, LIQUOR, or WATER.



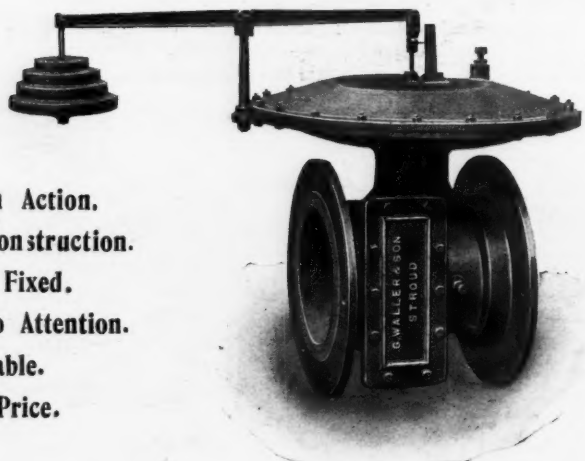
WALLER'S "PHŒNIX" DOUBLE ACTING STEAM PUMP,
Specially designed for Ammonia Liquor, Tar, and Thick Fluids; made in sizes from 3" × 2" × 3" to 12" × 9" × 18"

"Cameron" type (single & double) Steam Pumps. Piston Valve Pumps with Reversing Gear for Tar.
Batteries of Pumps.
Gas Engine Driven Pumps. Electrically Driven Pumps. Belt Driven Pumps.

THE

"REESON" PATENT RETORT-HOUSE GOVERNOR.

(MADE IN ALL SIZES.)



Perfect in Action.
Simple in Construction.
Easily Fixed.
Requires No Attention.
Durable.
Low Price.

No Cylindrical Valves to get Clogged with Tar.

No Bells of Sheet Metal to Corrode.

No Water Tanks to Keep Filled.

This Governor is arranged for being fixed in the Foul Main in the usual position, or on a Bye-Pass, and can be adjusted immediately. All parts are at once accessible, and readily removed, if desired. Governors of this type have been in constant use for over Two Years, giving perfect Registers.

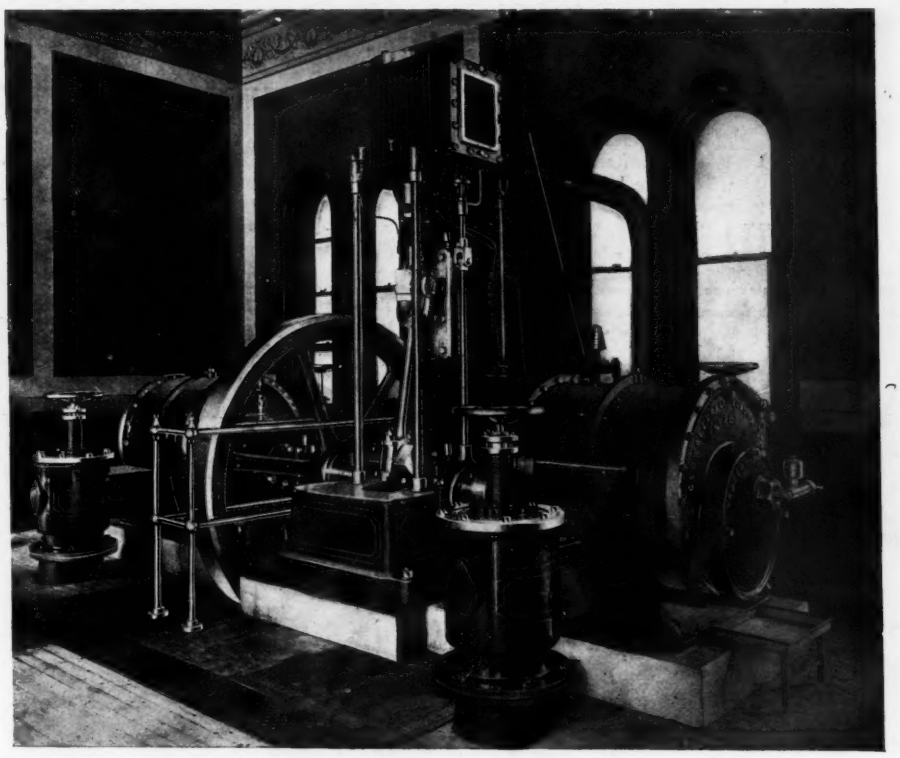
Write for Prices and Full Particulars—

GEO. WALLER & SON, STROUD, GLOUCESTERSHIRE.

Phœnix Iron Works,

(D. M. NELSON & CO., 53, Waterloo Street, Glasgow—Agents for Scotland.)

EXHAUSTING MACHINERY.



125,000 cubic feet Exhausters and Vertical Engine. Twin Set, Dv Type.

WALLER'S PATENT

3 AND 4 BLADE EXHAUSTERS

OVER 1400 SUPPLIED.

All Sizes from 500 to 500,000 Cubic Feet per hour. Maintain a steadier Gauge and require less Steam than any other Type.

GAS PRESSURE RAISING PLANTS.

(GAS, STEAM, AND ELECTRIC DRIVEN).

GAS VALVES of all Sizes and for all Purposes.

PINKNEY GAS ENGINES small power units. High Efficiency ¼ to 3 B.H.P.

COKE BREAKERS WITH OR WITHOUT Elevators, Screens, Storage Hoppers, &c.

ROTARY WASHER SCRUBBERS. LIVESEY WASHERS.

Sole Makers of "KERR" STEAM TURBINES.

GEO. WALLER & SON,

PHŒNIX IRON WORKS, STROUD, GLOUCESTERSHIRE.

(D. M. NELSON & Co., 53, Waterloo Street, GLASGOW.—Agents for Scotland.)

GUARANTEED PURE
"SHELL BRAND" GASHOLDER RED.

As used by EIGHTY PER CENT. of the Gas-Works in SCOTLAND as well as many in England and Ireland.

¶ Supplied in 7 or 3 cwt. Casks, 10 Gallon Tins or 7 and 14 lbs. Lever Lid Tins with Handles (as illustrated). We recommend the latter Packages for use when quantities of One cwt. or less are required, as the Tins are free and do not require to be returned and are handy for use as Paint Pots.

¶ We guarantee this Paint to be Pure Natural Oxide of Iron, ground and prepared with Pure Linseed Oil and American Turpentine only (no substitutes).

A. H. HAMILTON & CO., POSSIL PARK PAINT WORKS, GLASGOW.

GASHOLDERS

With Guide Frames or Spirally Guided.

CARBURETTED
WATER GAS PLANT.
STEEL TANKS.
STEEL PIPES.

Gas-Works Plant of every kind.

SAML. CUTLER & SONS,

Providence Ironworks, Millwall, London, E., and 39, Victoria Street, Westminster, S.W.

Telegrams: "RETORTUS, LONDON." Telephone: GERRARD 9492.

ROOFS,
STEEL
BUILDINGS,
CONDENSERS,
PURIFIERS,
JÄGER PATENT GRIDS.

Contractors to the

VERTICAL GAS RETORT SYNDICATE, LD.

No. 277

THE SILICA FIRE-BRICK COMPANY,

OUGHTIBRIDGE.

RADIATE MORE HEAT

BY USING

SILCO BRICK RETORTS.

SILCO BRICKS prevent all settling of setting.

SILICA BRICKS for Combustion Chambers, any shape.

Brilliance, Diffusion, Economy,

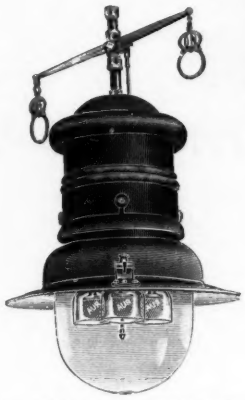


Fig. 623. Welsbach Inverted Storm-Proof Arc Lamp, giving 400-Candle Power. Price 52/6.

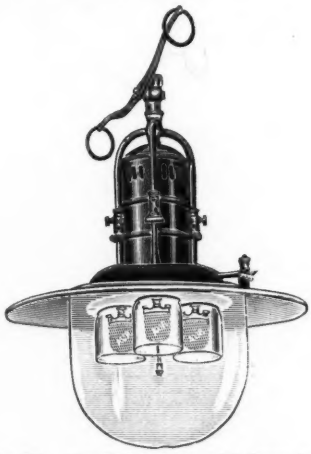


Fig. 624. The Welsbach Inverted Lamp for Interior Lighting, giving 400-Candle Power. Price 37/6.

The New Model Welsbach-Kern Inverted Burner gives 80-Candle Power for 3 feet of Gas per hour. Price 4/-.
The prettiest as well as the most efficient Inverted Burner on the Market. Complete as shown. Price 4/10½.

¶ are the Tests of the Efficiency of Modern Lighting Systems. Applied with thoroughness they leave Welsbach Lamps and Mantles in a position of pronounced and indisputable superiority.

¶ The life of the Welsbach Mantles is the Standard of Duration, the Type of prolonged Effective Service, and the Fittings are Patterns of Finish and Excellence.

¶ Welsbach Mantles are a perfect combination.

¶ No Black Shadows darkening the remoter parts of a Room or depriving Goods of the Light that Sells in Shop or Show-Room.

¶ Welsbach Lighting exemplifies reliability absolute and unqualified. The Retailer has to Offer no excuses. Satisfaction is spread by dealing in the Goods as the Goods themselves spread light—in uniform Quality and Quantity.

The Welsbach Mantles are "C," "CX," and "Plaissetty," Price 4½d. each, 4/3 per dozen; Inverted, 6d each, 5/- per dozen.

All Prices subject as usual.

HEAD OFFICES AND SHOW-ROOMS:

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Welsbach House, 344-354, Gray's Inn Road, London, W.C.

Telegrams and Cables: "WELSBACH, LONDON." Telephones: 2410 North (four lines).

THE CHEMICAL ENGINEERING CO.

79, Mark Lane, London, E.C.

Works: MIDLAND RAILWAY GOODS STATION, HENDON.

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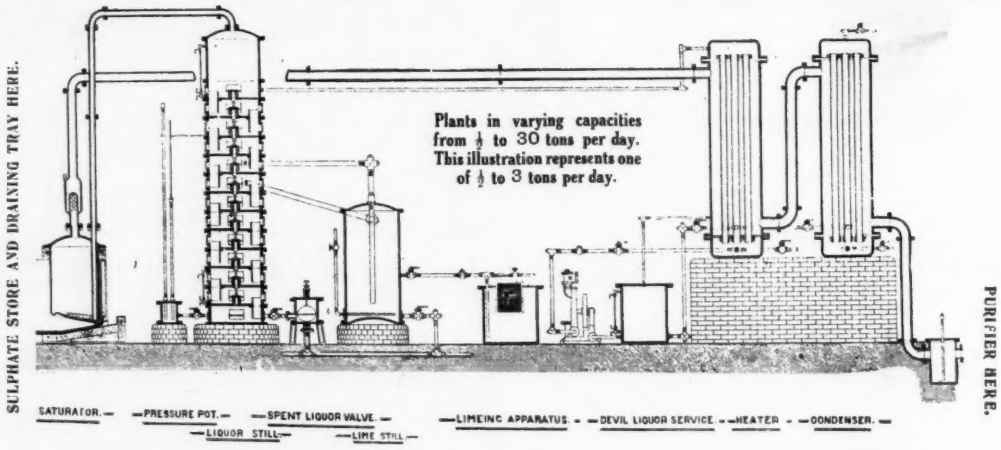
WILTON'S SULPHATE OF AMMONIA PLANT.



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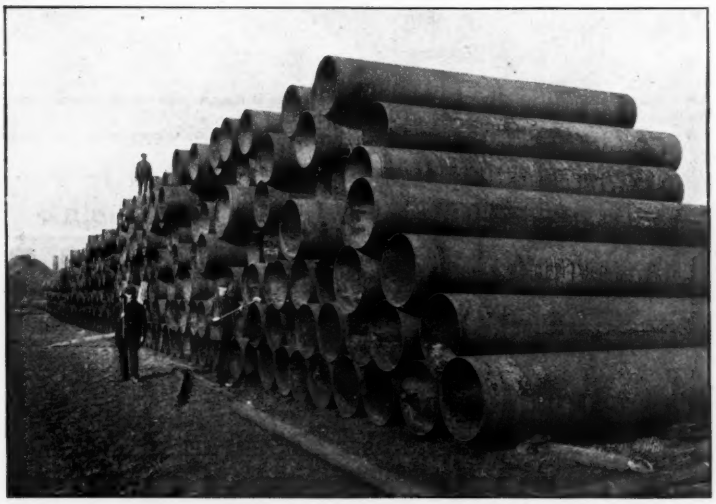

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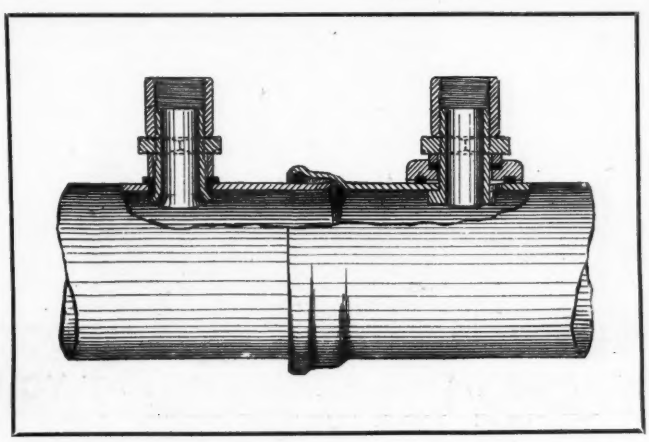

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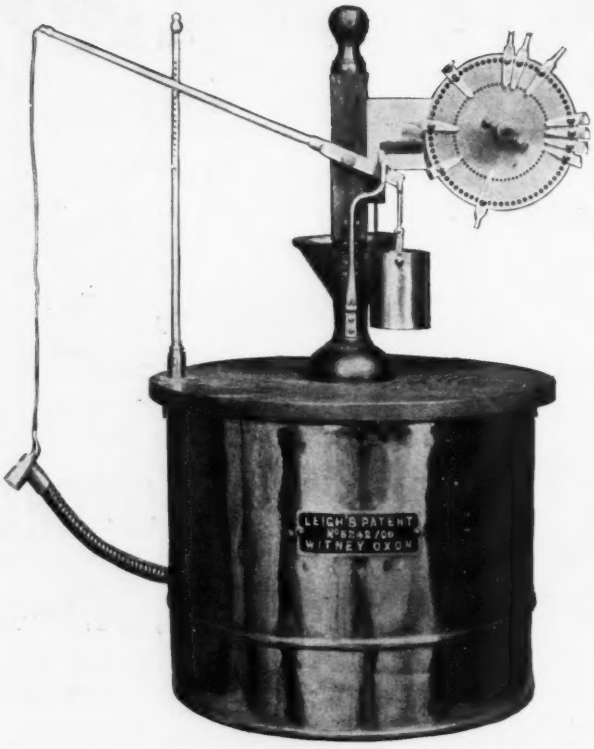

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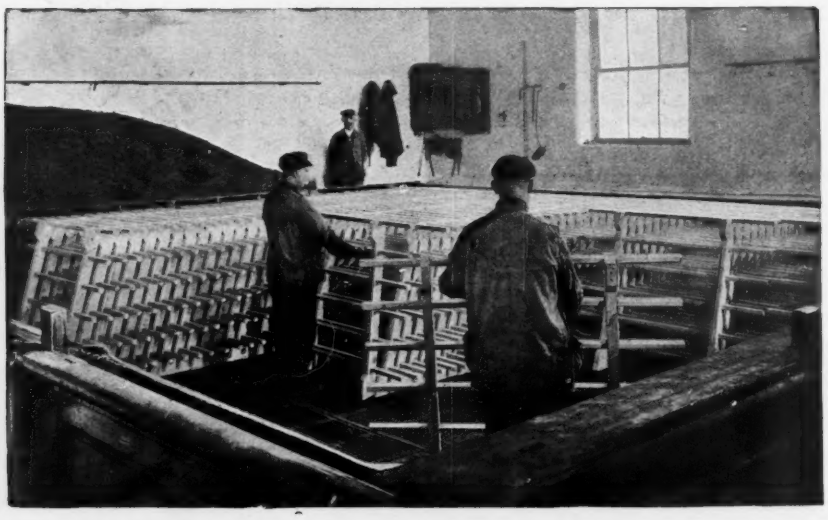

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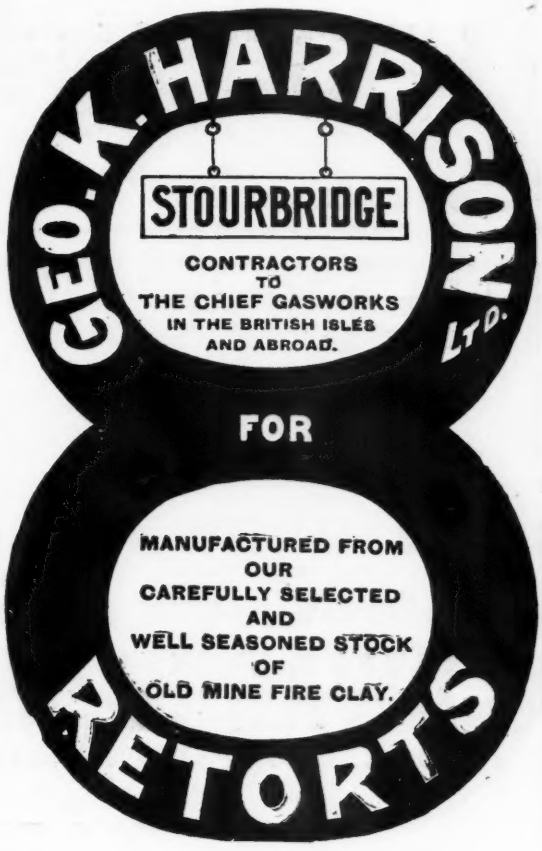
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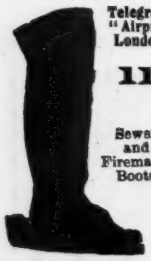

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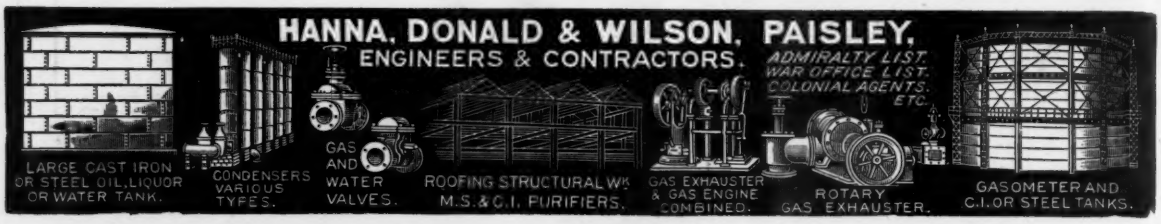
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